ESTD:2001

AEP

STUDY CIRCLE

UNIT OF ACCENT EDUCATIONAL PROMOTERS

OFFLINE-ONLINE LEARNING ACADEMY

CBSE pHySiCs

CURRENT ELECTRICITY

Q QND A

IIT MAINS & ADV

NEET

CBSE

NDA

CBSE pHySiCs

CURRENT ELECTRICITY

Q QND A

+91-9939586130

+91-7739650505

2ND FLOOR. SATKOUDI COMPLEX

THANA CHOWK, RAMGARH-829122

CURRENT ELECTRICITY
Q QND A

QUICK LOOK

Electric Current: Current is a tensor quantity, while current density is a vector. Conventionally direction of current is taken along the direction of flow of positive charges. In metals charge carriers are only free electrons. In liquids charge carriers are positive and negative ions. In gases charge carries are positive ions and electrons. And in semi-conductors charge carriers are electrons and holes.

Drift velocity of electrons in a metal is of the order of $10^{-3} m/s$ and is directly proportional to electric field (or potential difference applied). The current flows with speed of light. Mean velocity of electrons due to their thermal agitations (or random motion) is zero; while mean speed depends on temperature.

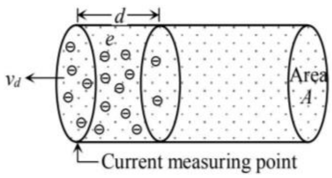


Figure: 16.1

Electric Current $I = \frac{q}{t} = \frac{dq}{dt}$ (scalar quantity)

Current Density $J = \frac{I}{A_n}$ where A_n = normal area

Current $I = \vec{j}.\vec{A} = JA\cos\theta = neAv_d$ where v_d is drift velocity.

Ohm's Law

Under same physical conditions the voltage is directly proportional to electric current in dc circuits. $V = Rl$ (Under same physical conditions)

- The resistance of a conductor is directly proportional to length and inversely proportional to cross-sectional area. i.e.
- At a given temperature, the specific resistance of a conductor is independent of dimensions but depends only on material.
- If a given mass of a material is stretched to decreases its cross-section, then its length also increase and then $R\alpha = \frac{l}{a}$ or $R\alpha \frac{l}{r^2}$

  Resistance $R = \frac{\rho l}{A} = \frac{2m}{ne^2\tau}.\frac{l}{A}$

Where
ρ = Specific resistance
τ = Relaxation time,
n = Electron density in meter^{-3}

Stretching of Wire: If a conducting wire stretches, it's length increases, area of cross-section decreases so resistance increases but volume remains constant.

Suppose for a conducting wire before stretching it's length $= l_1$, area of cross-section $= A_1$, radius $= r_1$, diameter $= d_1$, and resistance $R_1 = \rho\frac{l_1}{A_1}$

After stretching length $= l_2$, area of cross-section $= A_2$, radius $= r_2$, diameter $= d_2$ and resistance $= R_2 = \rho\frac{l_2}{A_2}$

Ratio of resistances before and after stretching

$$\frac{R_1}{R_2} = \frac{l_1}{l_2} \times \frac{A_2}{A_1} = \left(\frac{l_1}{l_2}\right)^2 = \left(\frac{A_2}{A_1}\right)^2 = \left(\frac{r_2}{r_1}\right)^4 = \left(\frac{d_2}{d_1}\right)^4$$

- If length is given then $R \propto l^2 \Rightarrow \frac{R_1}{R_2} = \left(\frac{l_1}{l_2}\right)^2$
- If radius is given then $R \propto \frac{1}{r^4} \Rightarrow \frac{R_1}{R_2} = \left(\frac{r_2}{r_1}\right)^4$
- Resistance of a conducting body is not unique but depends on it's length and area of cross-section *i.e.,* how the potential difference is applied. See the following figures

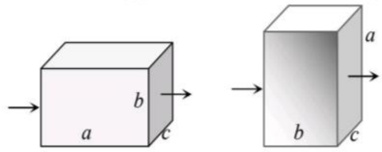


Figure: 16.2

For length = *a*, area of cross-section = $b \times c$

Resistance $R = \rho\left(\frac{a}{b \times c}\right)$

For length = *b*, Area of cross-section = $a \times c$

Resistance $R = \rho\left(\frac{b}{a \times c}\right)$

- Conductance $K = \frac{1}{R}$

- Specific resistance $\rho = \dfrac{ne^2\tau}{2m}$ (for metals)
- Conductivity $\sigma = \dfrac{1}{\rho} = \dfrac{2m}{ne^2\tau}$ (for metals)
- Ohm's Law $J = \sigma E$ (alternative form) or $V = Ri$. For Ohmic conductors (like iron, silver), $V - I$ graph is a straight line. And for non-ohmic conductors (like junction diode, torch bulb, thermistor)
  $V - I$ graph is non-linear

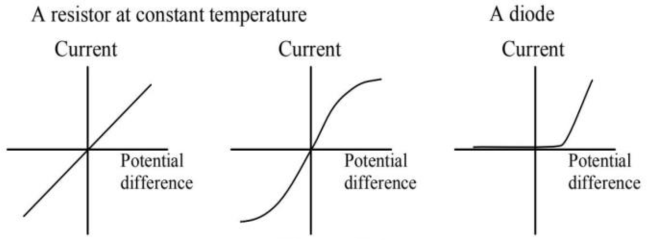


Figure: 16.3

- Effect of temperature on resistance: Generally metals offer more electrical resistance if temperature is increased. On the other hand the resistance offered by a non – metallic substance normally decreases with increase of temperature. $R_t = R_0(1 + \alpha t + \beta t^2); \alpha > \beta$
- For linear variation or if t is not too large $R_t = R_0(1 + \alpha t)$ For metals α is positive and for semi-conductor α is negative.

Combination of Resistances

- Resistance in series:
  Net resistance $R = R_1 + R_2 + R_3$
  Net potential difference, $V = V_1 + V_2 + V_3$
  Current $i = i_1 + i_2 + i_3$ (same in all resistance)
- Resistances in parallel:
  Net resistance R is given by $\dfrac{1}{R} = \dfrac{1}{R_1} + \dfrac{1}{R_2} + \dfrac{1}{R_3}$
  Net current $i = i_1 + i_2 + i_3$
  Potential difference $V = V_1 + V_2 + V_3$ (same across all resistances)

Note
Decoration of lights in festivals is an example of series grouping whereas all household appliances are connected in parallel grouping.

- Using n conductors of equal resistance, the number of possible combinations is 2^{n-1}.
- If the resistances of n conductors are totally different, then the number of possible combinations will be 2^n.
- If n identical resistances are first connected in series and then in parallel, the ratio of the equivalent resistance is given by $\dfrac{R_s}{R_p} = \dfrac{n^2}{1}$.
- If a wire of resistance R is cut in n equal parts and then these parts are collected to form a bundle, then equivalent resistance of combination will be $\dfrac{R}{n^2}$.
- If equivalent resistance of R_1 and R_2 in series and parallel be R_s and R_p respectively then

$$R_1 = \frac{1}{2}\left[R_s + \sqrt{R_s^2 - 4R_sR_p}\right]$$
$$R_2 = \frac{1}{2}\left[R_s - \sqrt{R_s^2 - 4R_sR_p}\right].$$

Internal Resistance r: Potential difference across the terinals of a cell $V = E - ir$ where r = internal resistance, E = *emf* of cell here $V = iR$. Internal resistance $r = \left(\dfrac{E}{V} - 1\right)R$ Where R = external resistance.

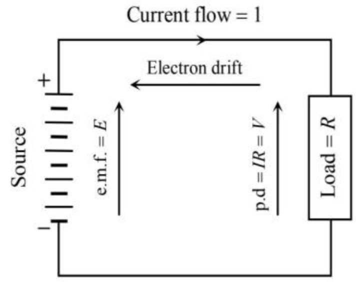


Figure: 16.4

Kirchoff's Laws

Kirchoff's first law (or current law) is based on conservation of charge. Junction Law: $\Sigma i = 0$ at any junction: Current law: the sum of the currents into any junction is equal to the sum of the current out.

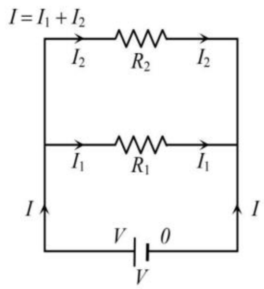


Figure: 16.5

For any branch of the circuit, the current out of the branch must be equal to the current into the branch. This is required by the conservation of electric charge. Any cross-section of the circuit must carry the total current. For a series circuit, the current is the same at any point in the circuit.

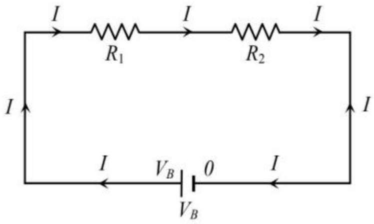


Figure: 16.6

Kirchoff's second law (or voltage law) is based on conservation of energy. Loop law $\Sigma V = 0$ or $\Sigma iR = \Sigma E$ for a closed circuit:

Voltage Law: The net voltage. Drop around any closed looppath must be zero.

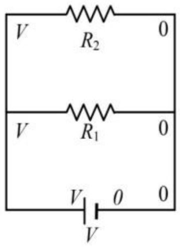


Figure: 16.7

For any path you follow around the circuit, the sum of the voltages rises (like batteries) must equal the sum of the voltage drops. Voltage represents energy per unit charge, and conservation of energy demands that energy is neither created nor destroyed.

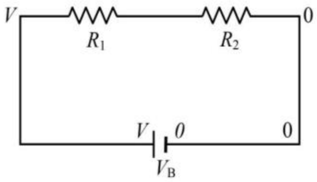


Figure: 16.8

Equivalent Resistance for Cube: If a skeleton cube is made with 12 equal resistances each having resistance R then the net resistance across

- The longest diagonal (AG or EC or BH or DF) $= \frac{5}{6}R$
- The diagonal of face (e.g. AC, ED… *etc.*) $= \frac{3}{4}R$
- A side (e.g. AB, BC etc.) $= \frac{7}{12}R$

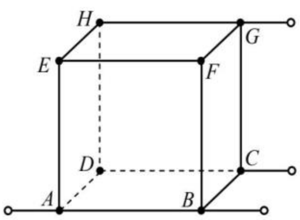


Figure: 16.9

Wheatstone's Bridge: When Wheatstone's bridge is balanced, the resistance in arm BD may be ignored while calculating the equivalent resistance of bridge between A and C.

- Condition of balance is $\frac{P}{Q} = \frac{R}{S}$
- Equivalent resistance between terminals connected to battery at balance $\frac{1}{R_{eq}} = \frac{1}{P+Q} + \frac{1}{R+S}$
- When battery and galvanometer arms of a Wheatstone's bridge are interchanged, the balance position remains undisturbed while sensitivity of bridge charges.
- A Wheatstone's bridge is most sensitive if its all resistance P, Q, R, S are equal.

Metre Bridge: Unknown resistance $S = \frac{100-1}{l} \times R$, where l = balancing length in cm

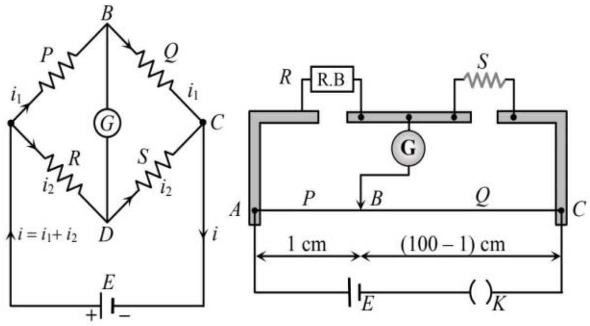


Figure: 16.10

Potentiometer: If L is length of potentiometer wire AB, Potential gradient $k = \frac{V_{AB}}{L} = i\rho$, where ρ is resistance per unit length of potentiometer wire

- EMF of a cell, $E = kl$
- For same potential gradient $\frac{E_1}{E_2} = \frac{l_1}{l_2}$

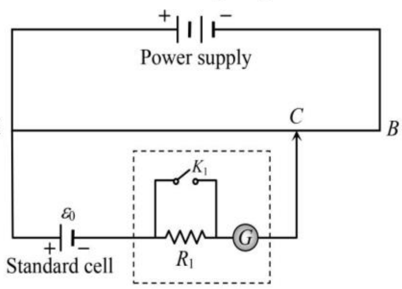


Figure: 16.11

Combinations of Cells

- **In series:** If n identical cells are in series $i = \frac{nE}{R+nr}$

  Where

$R =$ external resistance;
$r =$ internal resistance of a cell and
$E =$ emf of a cell

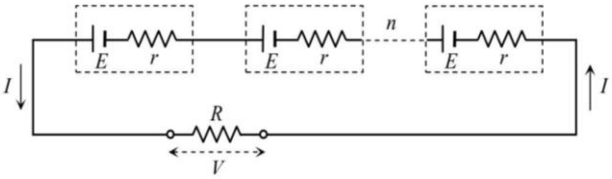


Figure: 16.12

- **In parallel:** n cells in parallel $i = \dfrac{E}{R + \left(\dfrac{r}{n}\right)}$

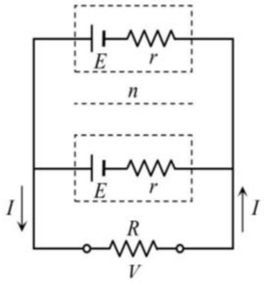


Figure: 16.13

- **Mixed grouping:** n cells in a now, m such rows in parallel $i = \dfrac{mnE}{mR + nr}$

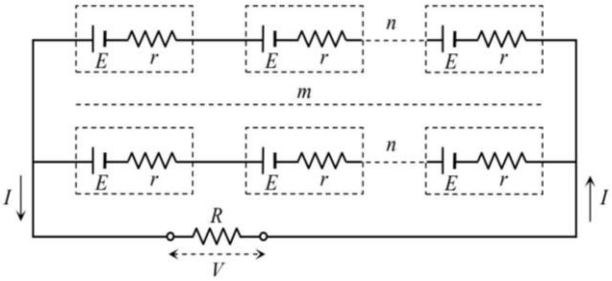


Figure: 16.14

For maximum current $R_{ext} = R_{\text{int}}$ or $R = \dfrac{nr}{m}$

- If two cells of different emfs are correctly connected in series $i = \dfrac{E_1 + E_2}{R + r_1 + r_2}$
- If two cells of different emfs are wrongly connected in series *i.e.,* (positive terminals connected together) $i = \dfrac{E_1 - E_2}{R + r_1 + r_2}$

Some Standard Results for Equivalent Resistance

Case (i):

$$R_{AB} = \frac{R_1R_2(R_3+R_4)+(R_1+R_2)R_3R_4+R_5(R_1+R_2)(R_3+R_4)}{R_5(R_1+R_2+R_3+R_4)+(R_1+R_3)(R_2+R_4)}$$

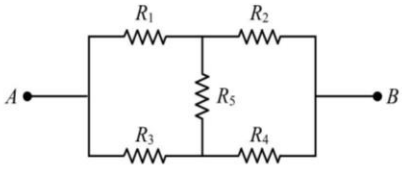


Figure: 16.15

Case (ii): $R_{AB} = \dfrac{2R_1R_2 + R_3(R_1+R_2)}{2R_3 + R_1 + R_2}$

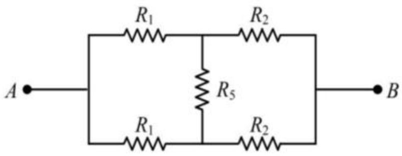


Figure: 16.16

Case (iii): $R_{AB} = \dfrac{1}{2}(R_1+R_2) + \dfrac{1}{2}\left[(R_1+R_2)^2 + 4R_3(R_1+R_2)\right]^{1/2}$

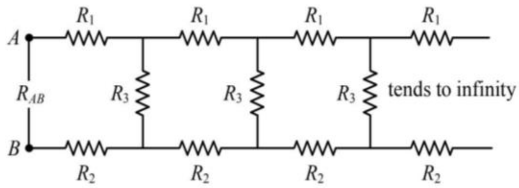


Figure: 16.17

Case (iv): $R_{AB} = \dfrac{1}{2}R_1\left[1 + \sqrt{1 + 4\left(\dfrac{R_2}{R_1}\right)}\right]$

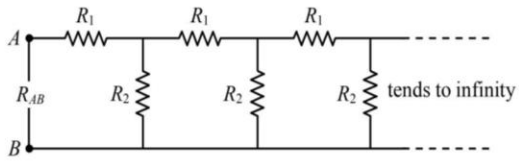


Figure: 16.18

- Transformation between Y or Star and delta connection

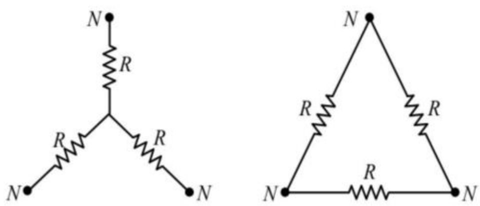


Figure: 16.19

- The transformation from Δ-load to Y-load. To compute the impedance R_y at a terminal node of the Y circuit with impedances R', R'' to adjacent node i $R_y = \dfrac{R'R''}{\Sigma R_\Delta}$n the Δ circuit by $R_y = \dfrac{R'R''}{\Sigma R_\Delta}$ where R_Δ are all impedances in the Δcircuit. This yields the specific formulae

$R_1 = \frac{R_b R_c}{R_a + R_b + R_c}$, $R_2 = \frac{R_a R_c}{R_a + R_b + R_c}$ and

$R_3 = \frac{R_a R_c}{R_a + R_b + R_c}$

- Equations for the transformation from Y-load to Δ -load
  The general idea is to compute an impedance R_Δ in the Δ circuit by $R_\Delta = \frac{R_p}{R_{opposite}}$

Where $R_p = R_1R_2 + R_2R_3 + R_3R_1$ is the sum of the products of all pairs of impedances in the Y circuit and $R_{opposite}$ is the impedance of the node in the Y circuit which is opposite the edge with R_Δ. The formula for the individual edges are thus

$R_a = \frac{R_1R_2 + R_2R_3 + R_3R_1}{R_1}$, $R_b = \frac{R_1R_2 + R_2R_3 + R_3R_1}{R_2}$ and

$R_c = \frac{R_1R_2 + R_2R_3 + R_3R_1}{R_3}$

$$Z_1 = \frac{Z_{12}Z_{13}}{Z_{12} + Z_{13} + Z_{23}}; \; Z_{12} = Z_1Z_2\left(\frac{1}{Z_1} + \frac{1}{Z_2} + \frac{1}{Z_3}\right)$$

Faraday's Laws

Mass of element deposited at electrode (i) $m = Zq = Zit$,

(ii) $\frac{m_1}{m_2} = \frac{W_1}{W_2}$

Z = Electrochemical equivalent, W = Chemical equivalent

Where $W = \frac{\text{atomic weight}}{\text{valency}}$

Faraday number $F = \frac{W}{Z} = 69500\text{Coul/g-equivalent}$

Thermo-electric Effects

A thermocouple is a temperature-measuring device consisting of two dissimilar conductors that contact each other at one or more spots, where a temperature differential is experienced by the different conductors (or semiconductors). It produces a voltage when the temperature of one of the spots differs from the reference temperature at other parts of the circuit. Thermocouples are a widely used type of temperature sensor for measurement and control, and can also convert a temperature gradient into electricity. Commercial thermocouples are inexpensive, interchangeable, are supplied with standard connectors, and can measure a wide range of temperatures. Seebeck effect is reversible. Seebeck effect is reversible. The direction of current in Cu-Fe thermocouple is for Cu to Fe through hot junction and in Bi- Sb couple it is form Bi to Sb through hot junction. Bi-Sb couple is most sensitive. Induced e.m.f. a thermo-couple $E = at + bt^2$

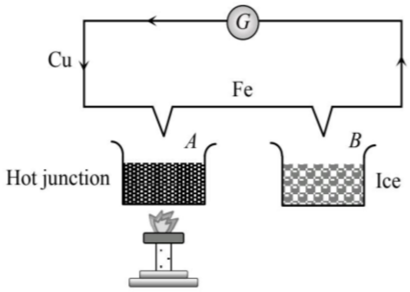


Figure: 16.20 Variation of thermo e.m.f. with temperature

Neutral temperature, $t_n = -\left(\frac{a}{2b}\right)°C$ Neutral temperature is independent of temperature of cold junction. At neutral temperature, the thermo e.m.f. is maximum; but thermoelectric power is zero.

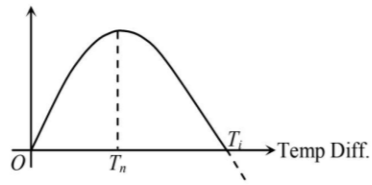


Figure: 16.21

Temperature of inversion depends on temperature of cold junction (t_0) $t_n - t_0 = t_i - t_n$

Inversion temperature when t_0 is 0° then $t_{i\ \text{is}} = 2t_n = -\left(\frac{a}{b}\right)°C$

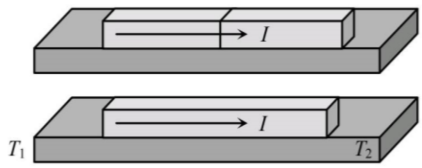


Figure: 16.22

- Thermoelectric power of a thermocouple, $P = \frac{dE}{dt} = a + bt$
- Peltier coefficient, $\pi = T\frac{dE}{dt}$
  $\Pi_{12}I \equiv$ Power evolved at junction
- Thomson coefficient, $\sigma = -T\frac{dP}{dt}$
  $\tau I \nabla T \equiv$ Power evolved per unit volume
- Thomson coefficient of lead is zero

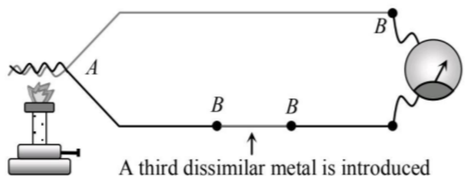


Figure: 16.23

- Law of Intermediate metals $E_{AB} + E_{BC} = E_{AC}$

MULTIPLE CHOICE QUESTIONS

Current Density (*J*)

1. The potential difference applied to an *X*-ray tube is 5 *KV* and the current through it is 3.2 *mA*. Then the number of electrons striking the target per second is:

a. 2×10^{16} **b.** 5×10^{6}
c. 1×10^{17} **d.** 4×10^{15}

2. A beam of electrons moving at a speed of 10^6 *m/s* along a line produces a current of 1.6×10^{-6} *A*. The number of electrons in the 1 *metre* of the beam is:

a. 10^6 **b.** 10^7
c. 10^{13} **d.** 10^{19}

3. An electron is moving in a circular path of radius 5.1×10^{-11} *m* at a frequency of 6.8×10^{15} revolution/sec. The equivalent current is approximately:

a. 5.1×10^{-3} *A* **b.** 6.8×10^{-3} *A*
c. 1.1×10^{-3} *A* **d.** 2.2×10^{-3} *A*

4. A copper wire of length 1*m* and radius 1*mm* is joined in series with an iron wire of length 2*m* and radius 3*mm* and a current is passed through the wire. The ratio of current densities in the copper and iron wire is:

a. 18 : 1 **b.** 9 : 1
c. 6 : 1 **d.** 2 : 3

5. A conducting wire of cross-sectional area 1 cm^2 has 3×10^{23} m^{-3} charge carriers. If wire carries a current of 24 *mA*, the drift speed of the carrier is:

a. 5×10^{-6} *m/s* **b.** 5×10^{-3} *m/s*
c. 0.5 *m/s* **d.** 5×10^{-2} *m/s*

6. In a wire of circular cross-section with radius *r*, free electrons travel with a drift velocity *v*, when a current *i* flows through the wire. What is the current in another wire of half the radius and of the some material when the drift velocity is 2*v*?

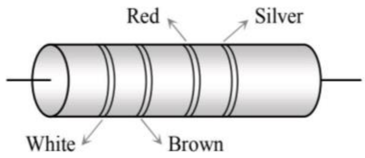
a. 2*i* **b.** *i*
c. $\frac{i}{2}$ **d.** $\frac{i}{4}$

7. 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 speeds of electrons in *A* and *B* is:

a. 16 : 1 **b.** 1 : 16
c. 1 : 4 **d.** 4 : 1

Electronics Colour Code

8. In the figure a carbon resistor has band of different colours on its body. The resistance of the following body is:



a. 2.2 *k*Ω **b.** 3.3 *k*Ω
c. 5.6 *k*Ω **d.** 9.1 *k*Ω

Ohm's Law and Resistance

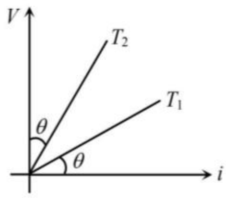
9. Two wires of resistance R_1 and R_2 have temperature co-efficient of resistance α_1 and α_2 respectively. These are joined in series. The effective temperature co-efficient of resistance is:

a. $\frac{\alpha_1 + \alpha_2}{2}$ **b.** $\sqrt{\alpha_1 \alpha_2}$
c. $\frac{\alpha_1 R_1 + \alpha_2 R_2}{R_1 + R_2}$ **d.** $\frac{\sqrt{R_1 R_2 \alpha_1 \alpha_2}}{\sqrt{R_1^2 + R_2^2}}$

10. A wire of length *L* and resistance *R* is stretched to get the radius of cross-section halved. What is new resistance?

a. 5 *R* **b.** 8 *R*
c. 4 *R* **d.** 16 *R*

11. The *V*-*i* graph for a conductor at temperature T_1 and T_2 are as shown in the figure. $(T_2 - T_1)$ is proportional to:



a. cos 2*θ* **b.** sin*θ*
c. cot 2*θ* **d.** tan*θ*

12. The resistance of a wire at 20°*C* is 20 Ω and at 500°*C* is 60Ω. At which temperature resistance will be 25Ω:

a. 50°*C* **b.** 60°*C*
c. 70°*C* **d.** 80°*C*

13. The specific resistance of manganin is $50 \times 10^{-8}\,\Omega m$. The resistance of a manganin cube having length 50 *cm* is:

a. 10^{-6} Ω **b.** 2.5×10^{-5} Ω
c. 10^{-8} Ω **d.** 5×10^{-4} Ω

14. A rod of certain metal is 1 *m* long and 0.6 *cm* in diameter. It's resistance is 3×10^{-3}Ω. A disc of the same metal is 1 *mm* thick and 2 *cm* in diameter, what is the resistance between it's circular faces.

a. $1.35 \times 10^{-6}\,\Omega$ **b.** $2.7 \times 10^{-7}\,\Omega$
c. $4.05 \times 10^{-6}\,\Omega$ **d.** $8.1 \times 10^{-6}\,\Omega$

15. An aluminum rod of length 3.14 m is of square cross-section $3.14 \times 3.14\ mm^2$. What should be the radius of 1 m long another rod of same material to have equal resistance:

a. 2 mm **b.** 4 mm
c. 1 mm **d.** 6 mm

16. If a copper wire is stretched to make it 0.1% longer, the percentage increase in resistance will be:

a. 0.2 **b.** 2
c. 1 **d.** 0.1

17. The temperature co-efficient of resistance of a wire is $0.00125/^oC$. At 300K. It's resistance is 1Ω. The resistance of the wire will be $2\,\Omega$ at:

a. 1154 K **b.** 1127 K
c. 600 K **d.** 1400 K

18. Masses of three wires are in the ratio 1 : 3 : 5 and their lengths are in the ratio 5 : 3 : 1. The ratio of their electrical resistance is:

a. 1 : 3 : 5 **b.** 5 : 3 : 1
c. 1 : 15 : 125 **d.** 125 : 15 : 1

19. Dimensions of a block are 1 cm × 1 cm × 100 cm. If specific resistance of its material is 3×10^{-7} ohm-m, then the resistance between it's opposite rectangular faces is:

a. 3×10^{-9} ohm **b.** 3×10^{-7} ohm
c. 3×10^{-5} ohm **d.** 3×10^{-3} ohm

20. A new flashlight cell of emf 1.5 $volts$ gives a current of 15 $amps$, when connected directly to an ammeter of resistance 0.04 Ω. The internal resistance of cell is:

a. 0.04 Ω **b.** 0.06 Ω
c. 0.10 Ω **d.** 10 Ω

21. For a cell, the terminal potential difference is 2.2 V when the circuit is open and reduces to 1.8 V, when the cell is connected across a resistance, $R = 5\Omega$. The internal resistance of the cell is:

a. $\frac{10}{9}\Omega$ **b.** $\frac{9}{10}\Omega$
c. $\frac{11}{9}\Omega$ **d.** $\frac{5}{9}\Omega$

22. The internal resistance of a cell of emf 2V is 0.1Ω. It's connected to a resistance of 3.9Ω. The voltage across the cell will be:

a. 0.5 $volt$ **b.** 1.9 $volt$
c. 1.95 $volt$ **d.** 2 $volt$

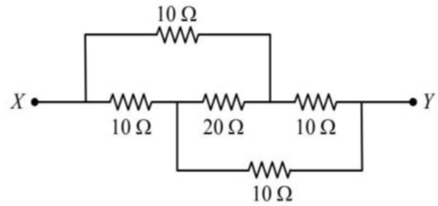
Kirchoff's Laws

23. Two resistance R_1 and R_2 provides series to parallel equivalents as $n/1$ then the correct relationship is:

a. $\left(\frac{R_1}{R_2}\right)^2 + \left(\frac{R_2}{R_1}\right)^2 = n^2$ **b.** $\left(\frac{R_1}{R_2}\right)^{3/2} + \left(\frac{R_2}{R_1}\right)^{3/2} = n^{3/2}$

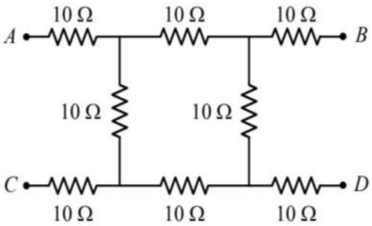
c. $\left(\frac{R_1}{R_2}\right) + \left(\frac{R_2}{R_1}\right) = n$ **d.** $\left(\frac{R_1}{R_2}\right)^{1/2} + \left(\frac{R_2}{R_1}\right)^{1/2} = n^{1/2}$

24. Five resistances are combined according to the figure. The equivalent resistance between the point X and Y will be:



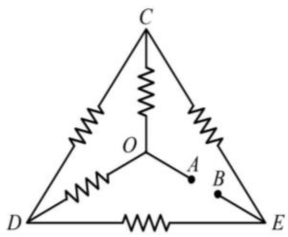
a. 10 Ω **b.** 22 Ω
c. 20 Ω **d.** 50 Ω

25. What will be the equivalent resistance of circuit shown in figure between points A and D:



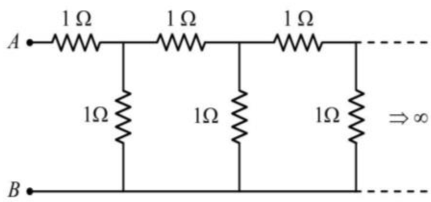
a. 10 Ω **b.** 20 Ω
c. 30 Ω **d.** 40 Ω

26. In the network shown in the figure each of resistance is equal to 2Ω. The resistance between A and B is:



a. 1 Ω **b.** 2 Ω **c.** 3 Ω **d.** 4 Ω

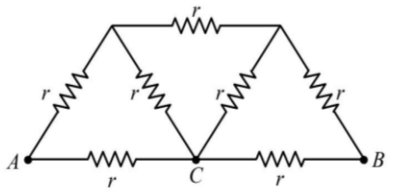
27. The equivalent resistance between points A and B of an infinite network of resistance, each of 1Ω, connected as shown is:



a. Infinite **b.** $2\ \Omega$

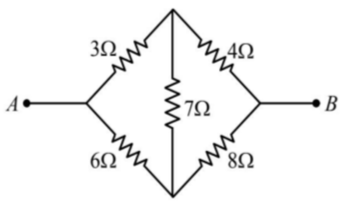
c. $\frac{1+\sqrt{5}}{2}\Omega$ **d.** Zero

28. The equivalent resistance between A and B in the circuit shown will be:



a. $\frac{5}{4}r$ **b.** $\frac{6}{5}r$ **c.** $\frac{7}{6}r$ **d.** $\frac{8}{7}r$

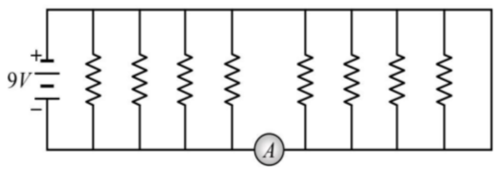
29. In the given figure, equivalent resistance between A and B will be:



a. $\frac{14}{3}\Omega$ **b.** $\frac{3}{14}\Omega$

c. $\frac{9}{14}\Omega$ **d.** $\frac{14}{9}\Omega$

30. If each resistance in the figure is of 9Ω then reading of ammeter is:



a. $5\ A$ **b.** $8\ A$

c. $2\ A$ **d.** $9\ A$

31. A wire has resistance 12Ω. It is bent in the form of a circle. The effective resistance between the two points on any diameter is equal to:

a. $12\ \Omega$ **b.** $6\ \Omega$

c. $3\ \Omega$ **d.** $24\ \Omega$

Combinations of Cells

32. In a mixed grouping of identical cells 5 rows are connected in parallel by each row contains 10 cell. This combination send a current i through an external resistance of 20Ω. If the emf and internal resistance of each cell is 1.5 *volt* and $1\ \Omega$ respectively then the value of i is:

a. 0.14 **b.** 0.25

c. 0.75 **d.** 0.68

33. To get maximum current in a resistance of $3\ \Omega$ one can use n rows of m cells connected in parallel. If the total no. of cells is 24 and the internal resistance of a cell is 0.5 then:

a. $m = 12, n = 2$ **b.** $m = 8, n = 4$

c. $m = 2, n = 12$ **d.** $m = 6, n = 4$

34. 100 cells each of emf $5V$ and internal resistance 1Ω are to be arranged so as to produce maximum current in a 25Ω resistance. Each row contains equal number of cells. The number of rows should be:

a. 2 **b.** 4 **c.** 5 **d.** 100

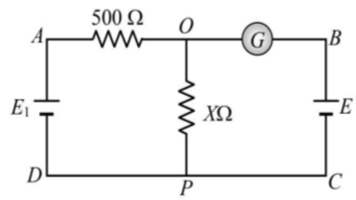
35. n identical cells, each of emf E and internal resistance r, are joined in series to form a closed circuit. The potential difference across any one cell is:

a. Zero **b.** E

c. $\frac{E}{n}$ **d.** $\left(\frac{n-1}{n}\right)E$

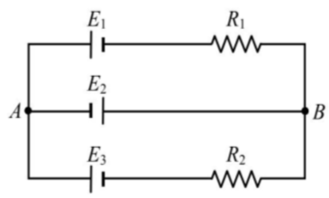
Network Simplification

36. In the adjoining circuit, the battery E_1 has as emf of 12 *volt* and zero internal resistance, while the battery E has an emf of 2 *volt*. If the galvanometer reads zero, then the value of resistance X *ohm* is:



a. 10 **b.** 100 **c.** 500 **d.** 200

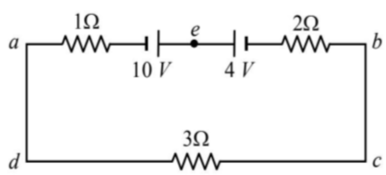
37. In the circuit shown here $E_1 = E_2 = E_3 = 2V$ and $R_1 = R_2 = 4\ \Omega$. The current flowing between point A and B through battery E_2 is:



a. Zero **b.** $2\ A$ from A to B

c. $2\ A$ from B to A **d.** None of these

38. The magnitude and direction of the current in the circuit shown will be:



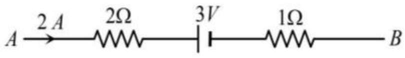
a. $\frac{7}{3}A$ from a to b through e

b. $\frac{7}{3}A$ from b and a through e

c. 1.0 A from b to a through e

d. 1.0 A from a to b through e

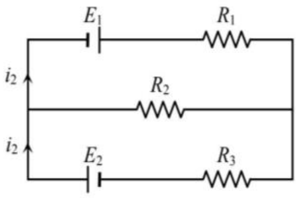
39. Figure represents a part of the closed circuit. The potential difference between points A and B ($V_A - V_B$) is:



a. + 9 V **b.** – 9 V

c. + 3 V **d.** + 6 V

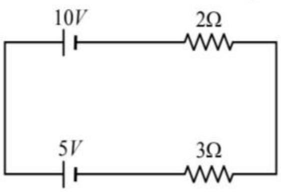
40. In the following circuit $E_1 = 4V$, $R_1 = 2\Omega$, $E_2 = 6V$, $R_2 = 2\Omega$ and $R_3 = 4\Omega$. The current i_1 is:



a. 1.6 A **b.** 1.8 A

c. 2.25 A **d.** 1 A

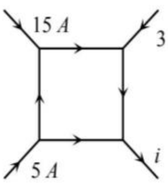
41. Determine the current in the following circuit:



a. 1 A **b.** 2.5 A

c. 0.4 A **d.** 3 A

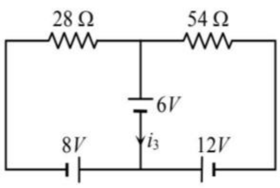
42. The figure shows a network of currents. The magnitude of current is shown here. The current i will be:



a. 3 A **b.** 13 A

c. 23 A **d.** – 3 A

43. Consider the circuit shown in the figure. The current i_3 is equal to:



a. 5 *amp* **b.** 3 *amp*

c. – 3 *amp* **d.** – 5/6 *amp*

Different Measuring Instruments

44. The scale of a galvanometer of resistance 100Ω contains 25 divisions. It gives a deflection of one division on passing a current of $4\times10^{-4}A$. The resistance in *ohms* to be added to it, so that it may become a voltmeter of range 2.5 *volt* is:

a. 100 **b.** 150 **c.** 250 **d.** 300

45. A galvanometer, having a resistance of 50 Ω gives a full scale deflection for a current of 0.05 A. the length in meter of a resistance wire of area of cross-section 2.97×10^{-2} cm^2 that can be used to convert the galvanometer into an ammeter which can read a maximum of 5A current is: (Specific resistance of the wire = 5×10^{-7} Ωm)

a. 9 **b.** 6 **c.** 3 **d.** 1.5

46. 100 *mA* current gives a full scale deflection in a galvanometer of resistance 2Ω. The resistance connected with the galvanometer to convert it into a voltmeter of 5 V range is:

a. 98 Ω **b.** 52 Ω

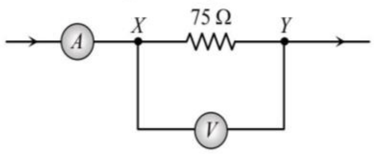
c. 80 Ω **d.** 48 Ω

47. A ammeter of range 10 *mA* has a coil of resistance 1Ω. To use it as voltmeter of range 10 *volt*, the resistance that must be connected in series with it will be:

a. 999 Ω **b.** 99 Ω

c. 1000 Ω **d.** None of these

48. In the following figure ammeter and voltmeter reads 2 *amp* and 120 *volt* respectively. Resistance of voltmeter is:



a. 100 Ω **b.** 200 Ω

c. 300 Ω **d.** 400 Ω

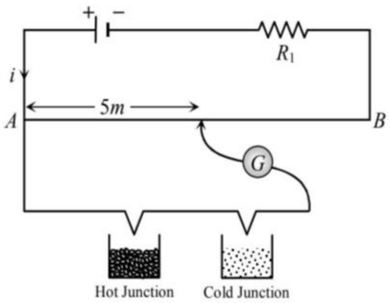
Potentiometer

49. A battery with negligible internal resistance is connected with 10m long wire. A standard cell gets balanced on 600 *cm* length of this wire. On increasing the length of potentiometer wire by 2m then the null point will be displaced by:

a. 200 *cm* **b.** 120 *cm*

c. 720 *cm* **d.** 600 *cm*

50. In the following circuit a 10 m long potentiometer wire with resistance 1.2 *ohm/m*, a resistance R_1 and an accumulator of emf 2 V are connected in series. When the emf of thermocouple is 2.4 mV then the deflection in galvanometer is zero. The current supplied by the accumulator will be:



a. 4×10^{-4} A **b.** 8×10^{-4} A
c. 4×10^{-3} A **d.** 8×10^{-3} A

51. The resistivity of a potentiometer wire is 40×10^{-8} Ωm and its area of cross section is 8×10^{-6} m^2. If 0.2 *amp.* Current is flowing through the wire, the potential gradient will be:

a. 10^{-2} *volt/m* **b.** 10^{-1} *volt/m*
c. 3.2×10^{-2} *volt/m* **d.** 1 *volt/m*

52. A deniel cell is balanced on 125 *cm* length of a potentiometer wire. When the cell is short circuited with a 2 Ω resistance the balancing length obtained is 100 *cm*. Internal resistance of the cell will be:

a. 1.5 Ω **b.** 0.5 Ω
c. 1.25 Ω **d.** 4/5 Ω

53. A potentiometer wire of length 10 *m* and a resistance 30 Ω is connected in series with a battery of emf 2.5 *V* and internal resistance 5 Ω and an external resistance *R*. If the fall of potential along the potentiometer wire is 50 $\mu V/mm$, the value of *R* is: (in Ω)

a. 115 **b.** 80
c. 50 **d.** 100

54. A 2 *volt* battery, a 15 Ω resistor and a potentiometer of 100 *cm* length, all are connected in series. If the resistance of potentiometer wire is 5 Ω, then the potential gradient of the potentiometer wire is:

a. 0.005 *V/cm* **b.** 0.05 *V/cm*
c. 0.02 *V/cm* **d.** 0.2 *V/cm*

55. In an experiment to measure the internal resistance of a cell by potentiometer, it is found that the balance point is at a length of 2 *m* when the cell is shunted by a 5 Ω resistance; and is at a length of 3 *m* when the cell is shunted by a 10 Ω resistance. The internal resistance of the cell is, then:

a. 1.5 Ω **b.** 10 Ω
c. 15 Ω **d.** 1 Ω

NCERT EXEMPLAR PROBLEMS

More than One Answer

56. Heater of an electric kettle is made of a wire of length *L* and diameter *d*. It takes 4 minutes to raise the temperature of 0.5 *kg* water by 40 *K*. This heater is replaced by a new heater having two wires of the same material, each of length *L* and diameter 2*d*. The way these wires are connected is given in the options. How much time in minutes will it take to raise the temperature of the same amount of water by 40 *K*?

a. 4 if wires are in parallel **b.** 2 if wires are in series
c. 1 if wires are in series **d.** 0.5 if wires are in parallel

57. Capacitor C_1 of capacitance 1μF and capacitor C_2 of capacitance 2μF are separately charged fully by a common battery. The two capacitors are then separately allowed to discharge through equal resistors at time $t = 0$:

a. The current in each of the two discharging circuits is zero at $t = 0$

b. The currents in the two discharging circuits at $t = 0$ are equal but not zero

c. The currents in the two discharging circuits at $t = 0$ are unequal

d. Capacitor C_1, loses 50% of its initial charge sooner than C_2 loses 50% of its initial charge

58. A micro ammeter has a resistance of 100 Ω and full scale range of 50μA. It can be used as a voltmeter or as a higher range ammeter provided a resistance is added to it. Pick the correct range and resistance combination(s):

a. 50 *V* range with 10 kΩ resistance in series

b. 10 *V* range with 200 kΩ resistance in series

c. 5 *mA* range with 1 Ω resistance in parallel

d. 10 *mA* range with 1 Ω resistance in parallel

59. When a potential difference is applied across, the current passing through:

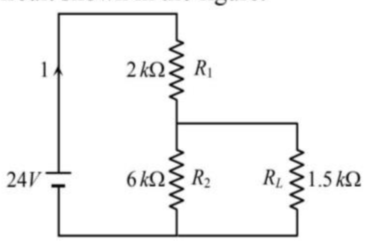
a. an insulator at 0 *K* is zero

b. a semiconductor at 0 *K* is zero

c. a metal at 0 *K* is finite

d. a *p-n* diode at 300 *K* is finite, if it is reverse biased

60. For the circuit shown in the figure:



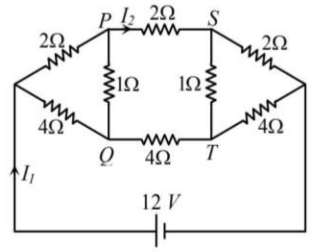
a. the current I through the battery is 7.5 mA

b. the potential difference across R_L is 18 V

c. ratio of powers dissipated in R_1 and R_2 is 3

d. if R_1 are interchanged, magnitude of the power dissipated in R_L will decrease by a factor of 9

61. For the resistance network shown in the figure, choose the correct options(s).



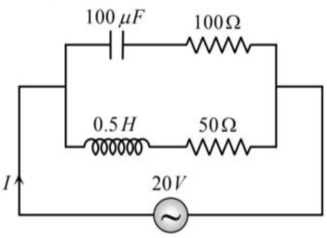
a. The current through PQ is zero

b. $I_1 = 3A$

c. The potential at S is less than that at Q

d. $I_2 = 2A$

62. In the given circuit, the AC source has $\omega = 100$ rad/s. Considering the inductor and capacitor to be ideal, the correct choice(s) is:(are)



a. The current through the circuit, I is 0.3 A

b. The current through the circuit, I is $0.3\sqrt{2}A$

c. The voltage across 100Ω resistor $= 10\sqrt{2}\,V$

d. The voltage across 50Ω resistor $= 10\ V$

63. When same quantity of electricity is passes through different electrolytes simultaneously, the masses of different element liberated are found to be proportional to their:

a. electrochemical equivalent **b.** chemical equivalent

c. atomic masses **d.** atomic numbers

64. When a potential difference is applied between the ends of a conductor:

a. the free electrons start moving

b. the free electrons are accelerated continuously from the lower potential end to higher potential end of the conductor

c. the free electrons acquire a constant drift velocity from the lower potential end to the higher potential end

d. ions starts vibrating with a larger amplitude

65. Two resistors having equal resistances are joined in series and a current is passed through the combination. Neglect any variation in resistance as the temperature changes. In a given time interval:

a. equal amounts of thermal energy must be produced in the resistors

b. unequal amounts of thermal energy may be produced

c. the temperature must rise equally in the resistors

d. the temperature may rise equally in the resistors

66. Which of the following statements is/are correct?

a. Resistance of the filament of a bulb is inversely proportional to the power of the bulb

b. Resistance of the filament of a bulb is directly proportional to the power of the bulb

c. Higher is the wattage of bulb, higher is the current that can be allowed to pass through a bulb

d. Higher is the wattage of bulb, lower is the current that can be allowed to pass through a bulb

67. Which of the following statements, concerning Kirchoff's laws, is/are correct?

a. In a network of conductors, the algebraic sum of currents meeting at any junction in the circuit is always equal to zero

b. Kirchoff's first law is an alternative form of the law of conservation of charge

c. In any closed mesh, the algebraic sum of the products of the currents and resistances of the different parts of the mesh is always equal to the algebraic sum of different e.m.f.'s acting in the mesh.

d. none of the above statement is correct

68. If three resistances R_1, R_2 and R_3 are joined in series through a battery, then:

a. equivalent resistance > highest individual resistance

b. current supplied by source = current in each resistance

c. applied potential difference is shared among the three resistance directly in their ratio

d. applied potential difference is shared among the three resistance inversely in their ratio

69. If three resistances R_1, R_2 and R_3 are joined in parallel across some potential source, then:

a. equivalent resistance < lowest individual resistance

b. applied potential difference = potential difference across each resistance

c. current supplied by the source is shared among three resistance inverselyin their ration

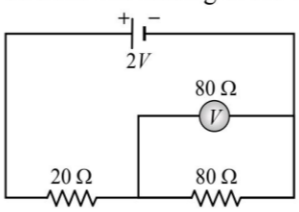
d. current supplied by the source is shared among three resistances directly in their ratio

70. In potentiometer experiments:
a. the wire must be uniform and must be very much long
b. e.m.f. of the battery in main circuit must be greater than e.m.f. to be measured
c. +*ve* terminals of the battery and cell must be connected at the same point
d. none of above

71. A wire of resistance R is cut into 'n' equal parts. These parts are then connected in parallel. The equivalent resistance of the combination will be:

a. nR **b.** $\frac{R}{n}$ **c.** $\frac{n}{R}$ **d.** $\frac{R}{n^2}$

72. In the adjoining circuit, the e.m.f. of the cell is 2 *volt* and the internal resistance is negligible. The resistance of the voltmeter is 80 *ohm*. The reading of the voltmeter will be:



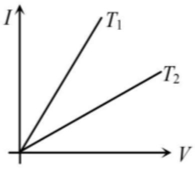
a. 0.80 *volt* b. 1.60 *volt*
c. 1.33 *volt* d. 2.00 *volt*

73. A steady current flows in a metallic conductor of non-uniform cross-section. The quantity/ quantities constant along the length of the conductor is/are:
a. Current, electric field and drift speed
b. Drift speed only
c. Current and drift speed **d.** Current only

Assertion and Reason

Note: Read the Assertion (A) and Reason (R) carefully to mark the correct option out of the options given below:
a. If both assertion and reason are true and the reason is the correct explanation of the assertion.
b. If both assertion and reason are true but reason is not the correct explanation of the assertion.
c. If assertion is true but reason is false.
d. If the assertion and reason both are false.
e. If assertion is false but reason is true.

74. **Assertion:** Figure shows the current-voltage (I–V) graphs for a given metallic wire at two different tempera-tures T_1 and T_2. It follows from the graphs that T_2 is greater than T_1.

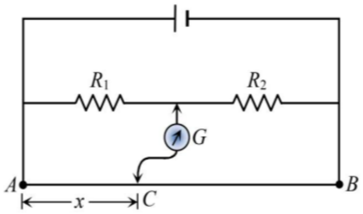


Reason: The resistance of a metallic conductor increases with increase in temperature.

75. **Assertion:** A 60 W bulb is connected in parallel with a room heater and this combination is connected across the mains. If the 60 W bulb is replaced by a 100 W bulb, the heat produced by the heater will remain the same.
Reason: When resistance are connected in parallel across the mains, the heat produced is inversely proportional to the resistance.

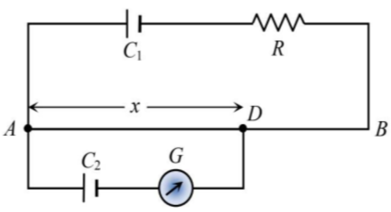
76. **Assertion:** If an electric field is applied to a metallic conductor, the free electrons experience a force but do not accelerate; they only drift at a constant speed.
Reason: The force exerted by the electric field is completely balanced by the Coulomb force between electrons and protons.

77. **Assertion:** In the metre bridge experiment shown in Fig., the balance length AC corresponding to null deflection of the galvanometer is x. If the radius of the wire AB is doubled, the balanced length becomes $4x$.



Reason: The resistance of a wire is inversely proportional to the square of its radius.

78. **Assertion:** In the potentiometer circuit shown in Fig. E_1 and E_2 are the emfs of cells C_1 and C_2 respectively with $E_1 > E_2$. Cell C_1 and C_2 respectively with $E_1 > E_2$. Cell C_1 has negligible internal resistance. For a given resistor R, the balance length is x. If the diameter of the potentiometer wire AB is increased, the balance length x will decrease.



Reason: At the balance point, the potential difference between AD due to cell $C_1 = E_2$, the emf of cell C_2.

79. **Assertion:** In the potentiometer circuit shown in above question, the wire AB is not changed but the value of resistor R is decreased. Then the balance length x will decrease.
Reason: At the balance point, the potential difference between A and D due to cell C_1 = emf E_2 of cell C_2.

80. Assertion: Electric appliances with metallic body have three connections, whereas an electric bulb has a two pin connection.
Reason: Three pin connections reduce heating of connecting wires.

81. Assertion: Bending a wire does not effect electrical resistance.
Reason: Resistance of wire is proportional to resistivity of material.

82. Assertion: Electric field outside the conducting wire which carries a constant current is zero.
Reason: Net charge on conducting wire is zero.

83. Assertion: The e.m.f. of the driver cell in the potentiometer experiment should be greater than the e.m.f. of the cell to be determined.
Reason: The fall of potential across the potentiometer wire should not be less than the e.m.f. of the cell to be determined.

84. Assertion: The temperature coefficient of resistance is positive for metals and negative for *p*-type semiconductor.
Reason: The effective charge carriers in metals are negatively charged whereas in *p*-type semiconductor they are positively charged.

85. Assertion: In a simple battery circuit the point of lowest potential is positive terminal of the battery
Reason: The current flows towards the point of the higher potential as it flows in such a circuit from the negative to the positive terminal.

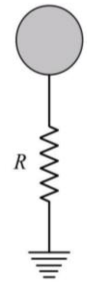
86. Assertion: The resistivity of a semiconductor increases with temperature.
Reason: The atoms of a semiconductor vibrate with larger amplitude at higher temperatures thereby increasing its resistivity

87. Assertion: The drift velocity of electrons in a metallic wire will decrease, if the temperature of the wire is increased.
Reason: On increasing temperature, conductivity of metallic wire decreases.

Comprehension Based

Paragraph –I

A conducting balloon of radius 'a' is charged to a potential V_0 and held at a large height above the earth surface. The large height of the balloon from the earth ensures that charge distribution on the surface of the balloon remains unaffected by the presence of the earth. It is connected to the earth through a resistance R and a valve in the balloon is opened. The gas inside the balloon escapes from the valve and the size of the balloon decreases. The rate of decrease in radius of the balloon is controlled in such a manner that potential of the balloon remains constant. Assume the electric permittivity of the surrounding air equals to that of free space (ε_0) and charge cannot leak to the surrounding air.



88. Rate at which radius r of the balloon changes with time is best represented by the equation:

a. $\frac{dr}{dt}=\frac{1}{4\pi\varepsilon_0 R}$ **b.** $\frac{dr}{dt}=-\frac{1}{4\pi\varepsilon_0 R}$

c. $\frac{dr}{dt}=\frac{r}{4\pi\varepsilon_0 aR}$ **d.** $\frac{dr}{dt}=-\frac{r}{4\pi\varepsilon_0 aR}$

89. How much heat is dissipated in the resistance R till the moment radius of the balloon becomes half?

a. $0.5\pi\varepsilon_0 aV_0^2$ **b.** $\pi\varepsilon_0 aV_0^2$

c. $2\pi\varepsilon_0 aV_0^2$ **d.** $4\pi\varepsilon_0 aV_0^2$

Paragraph -II

A thermal power plant produces electric power of 600 kW at 4000 V, which is to be transported to a place 20 km away from the power plant for consumers' usage. It can be transported either directly with a cable of large current carrying capacity or by using a combination of step-up and step-down transformers at the two ends. The drawback of the direct transmission is the large energy dissipation. In the method using transformers, the dissipation is much smaller. In this method, a step-up transformer is used at the plant side so that the current is reduced to a smaller value. At the consumers' end, a step-down transformer is used to supply power to the consumers at the specified lower voltage. It is reasonable to assume that the power cable is purely resistive and the transformers are ideal with the power factor unity. All the currents and voltage mentioned are rms values.

90. If the direct transmission method with a cable of resistance 0.4 Ω km^{-1} is used, the power dissipation (in %) during transmission is:

a. 20 **b.** 30 **c.** 40 **d.** 50

91. In the method using the transformers, assume that the ratio of the number of turns in the primary to that in the secondary in the step-up transformer is 1 : 10. If the power to the consumers has to be supplied at 200 V, the ratio of the number of turns in the primary to that in the secondary in the step-down transformer is:

a. 200 : 1 **b.** 150 : 1
c. 100 : 1 **d.** 50 : 1

ANSWER

1.	**2.**	**3.**	**4.**	**5.**	**6.**	**7.**	**8.**	**9.**	**10.**
a	b	c	b	b	c	a	d	c	d
11.	**12.**	**13.**	**14.**	**15.**	**16.**	**17.**	**18.**	**19.**	**20.**
c	d	a	b	c	a	b	d	b	b
21.	**22.**	**23.**	**24.**	**25.**	**26.**	**27.**	**28.**	**29.**	**30.**
a	c	d	a	c	b	c	d	a	a
31.	**32.**	**33.**	**34.**	**35.**	**36.**	**37.**	**38.**	**39.**	**40.**
c	d	a	a	a	b	b	d	a	b
41.	**42.**	**43.**	**44.**	**45.**	**46.**	**47.**	**48.**	**49.**	**50.**
a	c	d	b	c	d	a	c	b	a
51.	**52.**	**53.**	**54.**	**55.**	**56.**	**57.**	**58.**	**59.**	**60.**
a	b	a	a	b	b,d	b,d	b,c	a,b,d	a,d
61.	**62.**	**63.**	**64.**	**65.**	**66.**	**67.**	**68.**	**69.**	**70.**
a,b,d	a,c	a,b	c,d	a,d	a,c	a,b,c	a,b,c	a,b,c	a,b,c
71.	**72.**	**73.**	**74.**	**75.**	**76.**	**77.**	**78.**	**79.**	**80.**
c	c	d	a	a	c	d	d	a	e
81.	**82.**	**83.**	**84.**	**85.**	**86.**	**87.**	**88.**	**89.**	**90.**
b	a	c	b	d	d	b	b	c	b
91.	**92.**	**93.**	**94.**	**95.**	**96.**	**97.**	**98.**	**99.**	**100.**
a	a	c	a	5	7	6	2	4	6

SOLUTION

Multiple Choice Questions

1. **(a)** $i = \frac{q}{t} = \frac{ne}{t}$

$\Rightarrow \quad n = \frac{it}{e} = \frac{3.2\times10^{-3}\times1}{1.6\times10^{-19}} = 2\times10^{16}$

2. **(b)** $i = \frac{q}{t} = \frac{q}{(x/v)} = \frac{qv}{x} = \frac{nev}{x}$

$\Rightarrow \quad n = \frac{ix}{ev} = \frac{1.6\times10^{-6}\times1}{1.6\times10^{-19}\times10^{6}} = 10^{7}$

3. **(c)** $v = 6.8\times10^{15}$

$\Rightarrow \quad T = \frac{1}{6.8\times10^{15}}\,\text{sec}$

$\Rightarrow \quad i = \frac{Q}{T} = 1.6\times10^{-19}\times6.8\times10^{15} = 1.1\times10^{-3}\,A$

4. **(b)** We know $J = \frac{i}{A}$ when i = constant $J \propto \frac{1}{A}$

$\Rightarrow \quad \frac{J_c}{J_i} = \frac{A_i}{A_c} = \left(\frac{r_i}{r_c}\right)^2 = \left(\frac{3}{1}\right)^2 = \frac{9}{1}$

5. **(b)** $v_d = \frac{i}{neA} = \frac{24\times10^{-3}}{3\times10^{23}\times1.6\times10^{-19}\times10^{-4}} = 5\times10^{-3}\,m/s$

6. **(c)** $i = neAv_d = ne\pi r^2 v$

$\Rightarrow \quad i' = ne\pi\left(\frac{r}{2}\right)^2\cdot 2v = \frac{ne\pi r^2 v}{2} = \frac{i}{2}$

7. **(a)** As $i = neAv_d$

$\Rightarrow \quad \frac{i_1}{i_2} = \frac{A_1}{A_2}\times\frac{v_{d_1}}{v_{d_2}} = \frac{r_1^2}{r_2^2}\cdot\frac{v_{d_1}}{v_{d_2}} \Rightarrow \frac{v_{d_1}}{v_{d_2}} = \frac{16}{1}$

8. **(d)** $R = 91\times10^2 \pm 10\% \approx 9.1\,k\Omega$

9. **(c)** Suppose at $t^{o}C$ resistances of the two wires becomes R_{1t} and R_{2t} respectively and equivalent resistance becomes R_t. In series grouping $R_t = R_{1t} + R_{2t}$, also $R_{1t} = R_1(1 + \alpha_1 t)$ and $R_{2t} = R_2(1 + \alpha_2 t)$

$R_t = R_1(1 + \alpha_1 t) + R_2(1 + \alpha_2 t)$

$= (R_1 + R_2) + (R_1\alpha_1 + R_2\alpha_2)t$

$= (R_1 + R_2)\left[1 + \frac{R_1\alpha_1 + R_2\alpha_2}{R_1 + R_2}t\right]$

Hence effective temperature co-efficient is $\frac{R_1\alpha_1 + R_2\alpha_2}{R_1 + R_2}$.

10. **(d)** By using $\frac{R_1}{R_2} = \left(\frac{r_2}{r_1}\right)^4$

$\Rightarrow \quad \frac{R}{R'} = \left(\frac{r/2}{r}\right)^4 \Rightarrow R' = 16R$

11. **(c)** As we know, for conductors resistance $\propto$ Temperature.

From figure $R_1 \propto T_1$

$\Rightarrow \quad \tan\theta \propto T_1$

$\Rightarrow \quad \tan\theta = kT_1 \qquad \ldots(i)$

(k = constant) and $R_2 \propto T_2$

$\Rightarrow \quad \tan(90^{o} - \theta) \propto T_2$

$\Rightarrow \quad \cot\theta = kT_2 \qquad \ldots(ii)$

From equation (i) and (ii) $k(T_2 - T_1) = (\cot\theta - \tan\theta)$

$(T_2 - T_1) = \left(\frac{\cos\theta}{\sin\theta} - \frac{\sin\theta}{\cos\theta}\right) = \frac{(\cos^2\theta - \sin^2\theta)}{\sin\theta\cos\theta}$

$= \frac{\cos 2\theta}{\sin\theta\cos\theta} = 2\cot 2\theta \Rightarrow (T_2 - T_1) \propto \cot 2\theta$

12. **(d)** By using $\frac{R_1}{R_2} = \frac{(1+\alpha t_1)}{(1+\alpha t_2)}$

$\Rightarrow \quad \frac{20}{60} = \frac{1+20\alpha}{1+500\alpha} \Rightarrow \alpha = \frac{1}{220}$

Again by using the same formula for 20Ω and 25Ω

$\Rightarrow \quad \frac{20}{25} = \frac{\left(1+\frac{1}{220}\times20\right)}{\left(1+\frac{1}{220}\times t\right)} \Rightarrow t = 80°C.$

13. **(a)** $R = \rho\dfrac{l}{A} = \dfrac{50\times10^{-8}\times50\times10^{-2}}{(50\times10^{-2})^2} = 10^{-6}\,\Omega$

14. **(b)** By using $R = \rho\cdot\dfrac{l}{A};\ \dfrac{R_{\text{disc}}}{R_{\text{rod}}} = \dfrac{l_{\text{disc}}}{l_{\text{rod}}}\times\dfrac{A_{\text{rod}}}{A_{\text{disc}}}$

$\Rightarrow \quad \dfrac{R_{\text{disc}}}{3\times10^{-3}} = \dfrac{10^{-3}}{1}\times\dfrac{\pi(0.3\times10^{-2})^2}{\pi(10^{-2})^2}$

$\Rightarrow \quad R_{\text{disc}} = 2.7\times10^{-7}\,\Omega$

15. **(c)** By using $R = \rho\cdot\dfrac{l}{A} \Rightarrow l \propto A$

$\Rightarrow \quad \dfrac{3.14}{1} = \dfrac{3.14\times3.14\times10^{-6}}{\pi\times r^2}$

$\Rightarrow \quad r = 10^{-3}$, $m = 1\ mm$

16. **(a)** In case of streching $R \propto l^2$

So, $\dfrac{\Delta R}{R} = 2\dfrac{\Delta l}{l} = 2\times0.1 = 0.2$

17. **(b)** By using $R_t = R_0\,(1 + \alpha\Delta t)$

$\Rightarrow \quad \dfrac{R_1}{R_2} = \dfrac{1+\alpha t_1}{1+\alpha t_2}$

So, $\dfrac{1}{2} = \dfrac{1+(300-273)\alpha}{1+\alpha t_2} \Rightarrow t_2 = 854°C = 1127\ K$

18. **(d)** $R = \rho\dfrac{l}{A} = \rho\dfrac{l^2}{V} = \rho\dfrac{l^2}{m}\sigma \quad \left(\because \sigma = \dfrac{m}{V}\right)$

$R_1 : R_2 : R_3 = \dfrac{l_1^2}{m_1} : \dfrac{l_2^2}{m_2} : \dfrac{l_3^2}{m_3} = 25 : \dfrac{9}{3} : \dfrac{1}{5} = 125 : 15 : 1$

19. **(b)** Length $l = 1\ cm = 10^{-2}\ m$
Area of cross-section $A = 1\ cm \times 100\ cm$
$= 100\ cm^2 = 10^{-2}\ m^2$

Resistance $R = 3\times10^{-7}\times\dfrac{10^{-2}}{10^{-2}} = 3\times10^{-7}\,\Omega$

20. **(b)** By using $i = \dfrac{E}{R+r}$

$\Rightarrow \quad 15 = \dfrac{1.5}{0.04+r} \Rightarrow r = 0.06\,\Omega$

21. **(a)** In open circuit, $E = V = 2.2\ V$
In close circuit, $V = 1.8\ V$, $R = 5\Omega$

So, Internal resistance, $r = \left(\dfrac{E}{V}-1\right)R = \left(\dfrac{2.2}{1.8}-1\right)\times5$

$\Rightarrow \quad r = \dfrac{10}{9}\Omega$

22. **(c)** By using $r = \left(\dfrac{E}{V}-1\right)R$

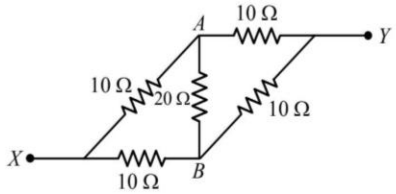
$\Rightarrow \quad 0.1 = \left(\dfrac{2}{V}-1\right)\times3.9 \Rightarrow V = 1.95\ volt$

23. **(d)** Series resistance $R_S = R_1 + R_2$ and parallel resistance $R_P = \dfrac{R_1R_2}{R_1+R_2}$

$\Rightarrow \quad \dfrac{R_S}{R_P} = \dfrac{(R_1+R_2)^2}{R_1R_2} = n \quad \Rightarrow \dfrac{R_1+R_2}{\sqrt{R_1R_2}} = \sqrt{n}$

$\Rightarrow \quad \dfrac{\sqrt{R_1^2}}{\sqrt{R_1R_2}} + \dfrac{\sqrt{R_2^2}}{\sqrt{R_1R_2}} = \sqrt{n} \Rightarrow \sqrt{\dfrac{R_1}{R_2}} + \sqrt{\dfrac{R_2}{R_1}} = \sqrt{n}$

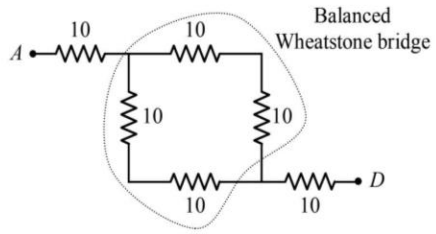
24. **(a)** The equivalent circuit of above can be drawn as. Which is a balanced wheatstone bridge. So current through *AB* is zero.



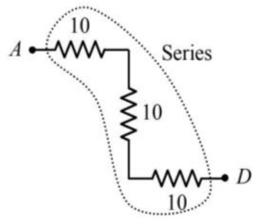
So, $\dfrac{1}{R} = \dfrac{1}{20} + \dfrac{1}{20} = \dfrac{1}{10}$

$\Rightarrow \quad R = 10\,\Omega$

25. **(c)** The equivalent circuit of above fig between *A* and *D* can be drawn as



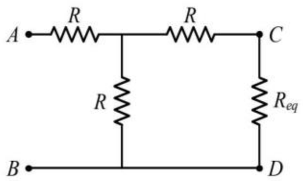
$\Rightarrow$



So, $R_{eq} = 10 + 10 + 10 = 30\Omega$

26. **(b)** Taking the portion *COD* is figure to outside the triangle (left), the above circuit will be now as resistance of each is 2Ω the circuit will behaves as a balanced wheatstone bridge and no current flows through *CD*. Hence $R_{AB} = 2\Omega$

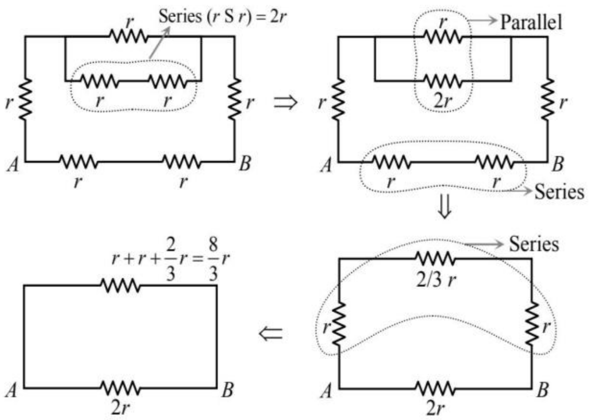
27. **(c)** Suppose the effective resistance between A and B is R_{eq}. Since the network consists of infinite cell. If we exclude one cell from the chain, remaining network have infinite cells *i.e.* effective resistance between C and D will also R_{eq}



So, Now $R_{eq} = R_o + (R \,||\, R_{eq}) = R + \dfrac{R R_{eq}}{R + R_{eq}}$

$\Rightarrow \quad R_{eq} = \dfrac{1}{2}[1 + \sqrt{5}]$

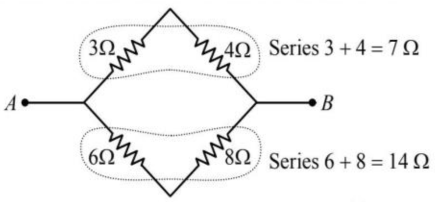
28. **(d)** In the circuit, by means of symmetry the point C is at zero potential. The equivalent circuit can be drawn as

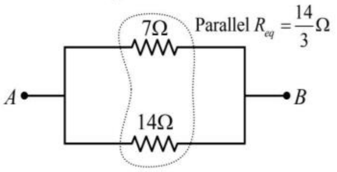


$\Rightarrow \quad R_{eq} = \left(\dfrac{8r}{3} \,||\, 2r\right) = \dfrac{8}{7}r$

29. **(a)** Given Wheatstone bridge is balanced because $\dfrac{P}{Q} = \dfrac{R}{S}$.

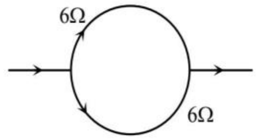
Hence the circuit can be redrawn as follows



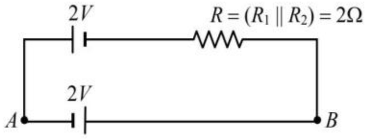


30. **(a)** Main current through the battery $i = \dfrac{9}{1} = 9A$. Current through each resistance will be $1A$ and only 5 resistances on the right side of ammeter contributes for passing current through the ammeter. So reading of ammeter will be $5A$.

31. **(c)** Equivalent resistance of the following circuit will be $R_{eq} = \dfrac{6}{2} = 3\Omega$



32. **(d)** No. of cells in a row $n = 10$; No. of such rows $m = 5$



$\Rightarrow \quad i = \dfrac{nE}{\left(R + \dfrac{nr}{m}\right)} = \dfrac{10 \times 1.5}{\left(20 + \dfrac{10 \times 1}{5}\right)} = \dfrac{15}{22} = 0.68\ amp$

33. **(a)** In this question $R = 3\Omega$, $mn = 24$, $r = 0.5\Omega$ and $R = \dfrac{mr}{n}$. On putting the values we get $n = 2$ and $m = 12$.

34. **(a)** Total no. of cells, $= mn = 100$ $\quad\quad$ . . . .(*i*)

Current will be maximum when $R = \dfrac{nr}{m}$; $25 = \dfrac{n \times 1}{m}$

$\Rightarrow \quad n = 25\,m$ $\quad\quad$ . . . (*ii*)

From equation (*i*) and (*ii*) $n = 50$ and $m = 2$

35. **(a)** Current in the circuit $i = \dfrac{nE}{nr} = \dfrac{E}{r}$

The equivalent circuit of one cell is shown in the figure. Potential difference across the cell

$= V_A - V_B = -E + ir = -E + \dfrac{E}{r}.r = 0$

36. **(b)** For zero deflection in galvanometer the potential different across X should be $E = 2V$

In this condition $\dfrac{12X}{500 + X} = 2$

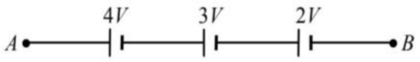
$\therefore \quad X = 100\ \Omega$

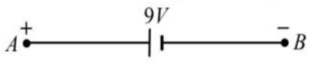
37. **(b)** The equivalent circuit can be drawn as since E_1 & E_3 are connected in parallel,

So, Current $i = \dfrac{2 + 2}{2} = 2\,Amp$ from A to B.

38. **(d)** Current $i = \dfrac{10 - 4}{3 + 2 + 1} = 1A$ from a to b via e

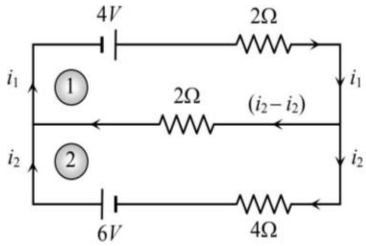
39. **(a)** The given part of a closed circuit can be redrawn as follows. It should be remember that product of current and resistance can be treated as an imaginary cell having emf $= iR$.



$\Rightarrow$ 

$\Rightarrow$ 7 Hence $V_A - V_B = +9\ V$

40. **(b)** For loop (1) $-2i_1 - 2(i_1 - i_2) + 4 = 0$



$\Rightarrow \quad 2i_1 - i_2 = 2 \qquad \ldots (i)$

For loop (2) $-4i_2 + 2(i_1 - i_2) + 6 = 0$

$\Rightarrow \quad 3i_2 - i_1 = 3 \qquad \ldots (ii)$

After solving equation (i) and (ii) we get $i_1 = 1.8\,A$ and $i_2 = 1.6\,A$

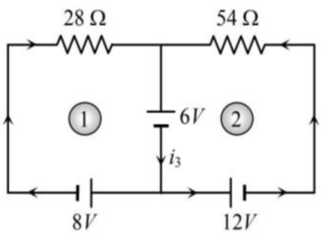
41. **(a)** Similar plates of the two batteries are connected together, so the net emf = 10 – 5 = 5V

Total resistance in the circuit = 2 + 3 = 5Ω

$\therefore \quad i = \frac{\Sigma V}{\Sigma R} = \frac{5}{5} = 1A$

42. **(c)** $i = 15 + 3 + 5 = 23A$

43. **(d)** Suppose current through different paths of the circuit is as follows.



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

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

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

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

44. **(b)** Current sensitivity of galvanometer $= 4\times10^{-4}$ *Amp/div.* So full scale deflection current (i_g) = Current sensitivity × Total number of division = $4 \times 10^{-4} \times 25 = 10^{-2}\ A$

To convert galvanometer in to voltmeter, resistance to be put in series is $R = \frac{V}{i_g} - G = \frac{2.5}{10^{-2}} - 100 = 150\Omega$

45. **(c)** Given $G = 50\ \Omega$, $i_g = 0.05\ Amp.$, $i = 5A$, $A = 2.97 \times 10^{-2}\ cm^2$ and $\rho = 5 \times 10^{-7}\Omega\text{-}m$

By using $\frac{i}{i_g} = 1 + \frac{G}{S}$

$\Rightarrow \quad S = \frac{G.i_g}{(i - i_g)} \Rightarrow \frac{\rho\, l}{A} = \frac{Gi_g}{(i - i_g)} \Rightarrow l = \frac{Gi_g A}{(i - i_g)\rho}$

On putting values $l = 3\ m$.

46. **(d)** $R = \frac{V}{I_g} - G = \frac{5}{100\times10^{-3}} - 2 = 50 - 2 = 48\Omega$

47. **(a)** By using $R = \frac{V}{ig} - G$

$\Rightarrow \quad R = \frac{10}{10\times10^{-3}} - 1 = 999\Omega$

48. **(c)** Let resistance of voltmeter be R_V. Equivalent resistance between X and Y is $R_{XY} = \frac{75R_V}{75 + R_V}$

Reading of voltmeter = potential difference across X and Y

$= 120 = i \times R_{XY}$

$= 2\times\frac{75R_V}{75 + R_V} \Rightarrow R_V = 300\Omega$

49. **(b)** By using $\frac{L_1}{L_2} = \frac{l_1}{l_2}$

$\Rightarrow \quad \frac{10}{12} = \frac{600}{l_2} \Rightarrow l_2 = 720\,cm.$

Hence displacement = 720 – 600 = 120 cm

50. **(a)** $E = x\,l = i\rho\, l$

$\therefore \quad i = \frac{E}{\rho l} = \frac{E}{\rho l} = \frac{2.4\times10^{-3}}{1.2\times5} = 4\times10^{-4}\,A.$

51. **(a)** Potential gradient $= \frac{V}{L} = \frac{iR}{L} = \frac{i\rho L}{AL} = \frac{i\rho}{A}$

$= \frac{0.2\times40\times10^{-8}}{8\times10^{-6}} = 10^{-2}\ V/m$

52. **(b)** By using $r = \frac{l_1 - l_2}{l_2}\times R'$

$\Rightarrow \quad r = \frac{125 - 100}{100}\times2 = \frac{1}{2} = 0.5\Omega$

53. **(a)** By using $x = \frac{e}{(R + R_h + r)}\cdot\frac{R}{L}$

$\Rightarrow \quad \frac{50\times10^{-6}}{10^{-3}} = \frac{2.5}{(30 + R + 5)}\times\frac{30}{10} \Rightarrow R = 115$

54. **(a)** By using $x = \dfrac{e}{(R+R_h+r)} \cdot \dfrac{R}{L}$

$\Rightarrow \quad x = \dfrac{2}{(5+15+0)} \times \dfrac{5}{1} = 0.5V/m = 0.005V/cm$

55. **(b)** By using $r = \left(\dfrac{l_1 - l_2}{l_2}\right)R'$

$\Rightarrow \quad r = \left(\dfrac{l_1 - 2}{2}\right) \times 5 \qquad \ldots (i)$

$r = \left(\dfrac{l_1 - 3}{3}\right) \times 10 \qquad \ldots (ii)$

On solving (*i*) and (*ii*) $r = 10\ \Omega$

NCERT Exemplar Problems

More than One Answer

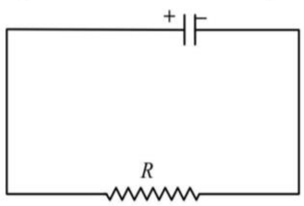
56. **(b, d)** $H = \dfrac{V^2}{R}4 = \dfrac{V^2}{R/2}t_1 \dfrac{V^2}{R/8}t_2$

$\Rightarrow \quad t_1 = 2\text{ min}. \quad \Rightarrow t_2 = 0.5\text{ min}.$

57. **(b, d)** The discharging current in the circuit is, $i = i_0 e^{-t/CR}$

Here, i_0 = initial current $= \dfrac{V}{R}$

Here, V is the potential with which capacitor was charged.



Since, V and R for both the capacitors are same, initial discharging current will be same but non-zero.

$\therefore$ Correct option is (b).

Further, $\tau_C = CR\ C_1 < C_2 \text{ or } \tau_{C_1} < \tau_{C_2}$

Or C_1 loses its 50% of initial charge sooner than C_2.

58. **(b, c)** To increase the range of ammeter a parallel resistance (called shunt) is required which is given by

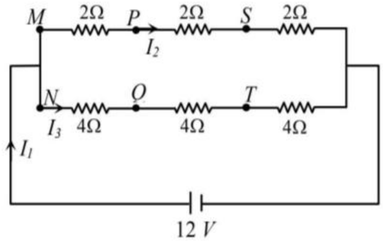
$S = \left(\dfrac{i_g}{i - i_g}\right)G$

For option (c) $S = \left(\dfrac{50\times10^{-6}}{5\times10^{-3} - 50\times10^{-6}}\right)(100) \approx 1\Omega$

To change it in voltmeter, a high resistance R is put in series, where R is given by $R = \dfrac{V}{i_g} - G$

For option (b) $R = \dfrac{10}{50\times10^{-6}} - 100 \approx 200k\Omega$

59. **(a, b, d)** $R_{total} = 2 + \dfrac{6\times1.5}{6+1.5} = 3.2k\Omega$



(a) $I = \dfrac{24V}{3.2k\Omega} = 7.5mA = I_{R_1}$

$\Rightarrow \quad I_{R_2} = \left(\dfrac{R_L}{R_L + R_2}\right)I \Rightarrow I = \frac{1.5}{7.5} \times 7.5 = 1.5mA$

$\Rightarrow \quad I_{R_L} = 6mA$

(b) $V_{R_L} = (I_{R_L})(R_L) = 9V$

(c) $\dfrac{P_{R_1}}{P_{R_2}} = \dfrac{(I_R^2)R_1}{(I_R^2)R_2} = \dfrac{(7.5)^2(2)}{(1.5)^2(6)} = \dfrac{25}{3}$

(d) When R_1 and R_2 are inter changed, then

$\dfrac{R_2 R_L}{R_2 + R_L} = \dfrac{2\times1.5}{3.5} = \dfrac{6}{7}k\Omega$. Now potential difference across R_L will be $V_L = 24\left[\dfrac{6/7}{6+6/7}\right] = 3V$

Earlier it was 9 V

Since, $P = \dfrac{V^2}{R}$ or $P \propto V^2$

In new situation potential difference has been decreased three times. Therefore, power dissipated will decrease by a factor of 9.

60. **(a, d)** the current I through the battery is 7.5 mA. if R_1 are interchanged, magnitude of the power dissipated in R_L will decrease by a factor of 9.

61. **(a, b, d)** Due to symmetry on upper side and lower side, points P and Q are at same potentials. Similarly, points S and T are at same potentials. Therefore, the simple circuit can be drawn as shown below

$I_2 = \dfrac{12}{2+2+2} = 2A$ or $I_3 = \dfrac{12}{4+4+4} = 1A$

$\therefore \quad I_1 = I_2 + I_3 = 3A \qquad \Rightarrow I_{PQ} = 0$

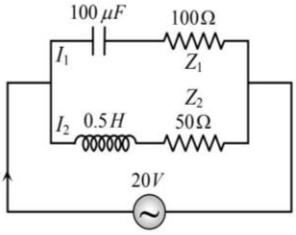
Because $V_P = V_Q$

Potential drop (from left to right) across each resistance is

$\dfrac{12}{3} = 4V$

$\therefore \quad V_{MS} = 2\times4 = 8V \Rightarrow V_{NQ} = 1\times4 = 4V$ or $V_S < V_Q$

62. **(a, c)** Circuit 1- $X_C = \frac{1}{\omega C} = 100\Omega$



$\therefore \quad Z_1 = \sqrt{(100)^2 + (100)^2} = 100\sqrt{2}\Omega$

$\phi_1 = \cos^{-1}\left(\frac{R_1}{Z_1}\right) = 45°$

In this circuit current leads the voltage.

$I_1 = \frac{V}{Z_1} = \frac{20}{100\sqrt{2}} = \frac{1}{5\sqrt{2}} A$

$V_{100\Omega} = (100)I_1 = (100)\frac{1}{5\sqrt{2}} V = 10\sqrt{2}V$

Circuit 2- $X_L = \omega L = (100)(0.5) = 50\Omega$

$Z_2 = \sqrt{(50)^2 + (50)^2} = 50\sqrt{2}\Omega \Rightarrow \phi_2 = \cos^{-1}\left(\frac{R_2}{Z_2}\right) = 45°$

In this circuit voltage leads the current.

$I_2 = \frac{V}{Z_2} = \frac{20}{50\sqrt{2}} = \frac{\sqrt{2}}{5} A$

$V_{50\Omega} = (50)I_2 = 50\left(\frac{\sqrt{2}}{5}\right) = 10\sqrt{2}V$

Further, I_1 and I_2 have a mutual phase difference of 90°

$\therefore \quad I = \sqrt{I_1^2 + I_2^2} = \sqrt{\frac{1}{50} + \frac{4}{50}} = \frac{1}{\sqrt{10}} A \approx 0.3A$

63. **(a, b)** According to faraday's laws: $\frac{m_1}{m_2} = \frac{W_1}{W_2} = \frac{Z_1}{Z_2}$

64. **(c, d)** When a potential difference is applied between the two ends of a conductor, the electrons at every point of conductor are accelerated but for a very short interval of time $(= \tau)$. After that electrons always collide with some + *ve* ion and lose their velocity *i.e.* electrons move with an average velocity called as drift velocity and as a result of their collisions with + *ve* ions amplitude of vibrations of + *ve* ions is increased.

65. **(a, d)** equal amounts of thermal energy must be produced in the resistors. the temperature may rise equally in the resistors.

66. **(a,c)** Resistance of the filament of a bulb is inversely proportional to the power of the bulb. Higher is the wattage of bulb, higher is the current that can be allowed to pass through a bulb.

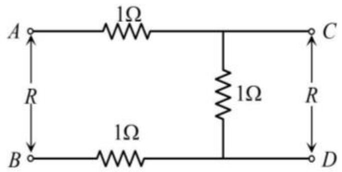
67. **(a,b,c)** In a network of conductors, the algebraic sum of currents meeting at any junction in the circuit is always equal to zero. Kirchoff's first law is an alternative form of the law of conservation of charge. In any closed mesh, the algebraic sum of the products of the currents and resistances of the different parts of the mesh is always equal to the algebraic sum of different e.m.f.'s acting in the mesh.

68. **(a,b,c)** equivalent resistance > highest individual resistance. current supplied by source = current in each resistance. applied potential difference is shared among the three resistance directly in their ratio.

69. **(a,b,c)** equivalent resistance < lowest individual resistance. applied potential difference = potential difference across each resistance. current supplied by the source is shared among three resistance inverselyin their ration.

70. **(a, b, c)** the wire must be uniform and must be very much long. e.m.f. of the battery in main circuit must be greater than e.m.f. to be measured. +*ve* terminals of the battery and cell must be connected at the same point.

71. **(c)** Let equivalent resistance between *A* and *B* be *R*, then equivalent resistance between *C* and *D* will also be *R*.



$\Rightarrow \quad R' = \frac{R}{R+1} + 2 = R$ or $R^2 - 2R - 2 = 0$

$\therefore \quad R = \frac{2 \pm \sqrt{4+8}}{2} = \sqrt{3} + 1$

72. **(c)** Total resistance of the circuit $= \frac{80}{2} + 20 = 60\Omega$

$\Rightarrow$ Main current $i = \frac{2}{60} = \frac{1}{30} A$

Combination of voltmeter and 80Ω resistance is connected in series with 20Ω,

So, current through 20Ω and this combination will be same $= \frac{1}{30} A$. Since the resistance of voltmeter is also 80Ω, so this current is equally distributed in 80Ω resistance and voltmeter (*i.e.* $\frac{1}{60}$ A through each)

P.D. across 80 Ω resistance $= \frac{1}{60} \times 80 = 1.33V$

73. **(d)** If E be electric field, then current density $j = \sigma E$

Also we know that current density $j = \frac{i}{A}$ Hence j is different for different area of cross-sections. When j is different, then E is also different. Thus E is not constant.

The drift velocity v_d is given by $v_d = \frac{j}{ne}$ = different for different j values. Hence only current i will be constant.

Assertion and Reason

74. **(a)** From Ohm's law, the slope of the $I - V$ gives the reciprocal of the resistance of the wire.
Since the slope of the graph is smalle at temperature T_2, the resistance of the wire is greater at temperature T_2 than at temperature T_1. Hence T_2 is greater than T_1.

75. **(a)** When a bulb and a heater a connected in parallel and this combination is connected across the main, potential difference across each is the same equal to the voltage V of the mains, irrespective of the resistance of the bulb. If R is the resistance of the heater, the rate at which heat is produced will be V^2/R in both cases.

76. **(c)** The electrons suffer a large number of collisions with the positive ions of the conductor. Although the electric field accelerates an electron between two collisions, it is decelerated by collision. The net acceleration averages out to zero and the electron acquires a constant average speed. The gain in speed between collisions is lost in the next collision

77. **(d)** The condition for no deflection of the galvanometer is $\frac{R_1}{R_2} = \frac{R_{AC}}{R_{CB}}$ where R_{AC} and R_{CB} are the resistances of the bridge wire of length AC and CB respectively.If the radius of the wire AB is doubled, the ratio R_{AC}/R_{CB} will remain unchanged. Hence the balance length will remain the same.

78. **(d)** If the diameter of wire AB is increased, its resistance will decrease. Hence, the potential difference between A and B due to cell C_1 will decrease. Therefore, the null point will be obtained at a higher value of x.

79. **(a)** If the value of R is decreased, the potential difference between A and B due to cell C_1 will increase. Hence the balance length will be smaller than x.

80. **(e)** Voltage of dc source is constant but in ac, peak value of voltage is $\sqrt{2}$ times the *rms*. voltage. Hence bulb will glow with more brightness when connected to an ac source of the same voltage.

81. **(b)** Neutral temperature is the temperature of hot junction, at which the thermo e.m.f. produced in the thermocouple becomes maximum. It is independent of cold junction and depends on the nature of materials of two metals used to form thermocouple.

82. **(a)** When lamp B or C gets fused equivalent resistance of B and C increases. In series voltage distributes in the ratio of resistance, so voltage appears across B increases or in other words voltage across A decreases.

83. **(c)** The electrical appliances with metallic body like heater, press *etc*. have three pin connections. Two pins are for supply line and third pin is for earth connection for safety purposes.

84. **(b)** The temperature co-efficient of resistance for metal is positive and that for semiconductor is negative. In metals free electrons (negative charge) are charge carriers while in P-type semiconductors, holes (positive charge) are majority charge carriers.

85. **(d)** It is quite clear that in a battery circuit, the point of lowest potential is the negative terminal of the battery and the current flows from higher potential to lower potential.

86. **(d)** Resistivity of a semiconductor decreases with the temperature. The atoms of a semiconductor vibrate with larger amplitudes at higher temperatures thereby increasing it's conductivity not resistivity.

87. **(b)** On increasing temperature of wire the kinetic energy of free electrons increase and so they collide more rapidly with each other and hence their drift velocity decreases. Also when temperature increases, resistivity increase and resistivity is inversely proportional to conductivity of material.

Comprehension Based

88. **(b)** $\frac{dr}{dt} = -\frac{1}{4\pi\varepsilon_0 R}$

89. **(c)** $2\pi\varepsilon_0 a V_0^2$

90. **(b)** For direction transmission $P = i^2R = (150)^2(0.4\times 20)$

$= 1.8\times 10^5 w$

Fraction (in %) $= \frac{1.8\times 10^5}{6\times 10^5}\times 100 = 30\%$

91. **(a)** $40000/200 = 200$

Match the Column

92. **(a)** A→3, B→2, C→1, D→4

93. **(c)** A→2, B→1, C→3, D→4

94. **(a)** A→ 1; B → 2,4; C → 2,4; D → 2,3,4

Integer

95. **(5)** Let E_0 be the potential difference applied across the total length l (= 10 cm) of potentiometer wire.

Potential gradient in the first case = $\frac{E_0}{l}$

As per question, $E = \frac{l}{3}\left(\frac{E_0}{l}\right) = \frac{E_0}{3}$ . . .(*i*)

Potential gradient in second case $= \frac{E_0}{3l/2} = \frac{2E_0}{3l}$.

If x is the desired length of potentiometer to balance the emf E of the cell, then $E = x \times \frac{2E_0}{3l}$ . . .(*ii*)

From (*i*) and (*ii*), we have $\frac{E_0}{3} = x \times \frac{2E_0}{3l}$ or $\frac{l}{2} = \frac{10}{2} = 5cm$.

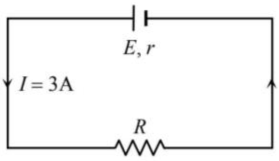
96. **(7)** When the current through galvanometer is zero, then

Potential difference across $R\ \Omega = 7$ V

Potential difference across $5\ \Omega = 12 - 7 = 5$ V

Current in $5\ \Omega = \frac{5}{5} = 1$ A, Resistance, $R = \frac{7}{1} = 7\ \Omega$.

97. **(6)** Refer Fig., there will be maximum power in the external circuit if $R = r$.



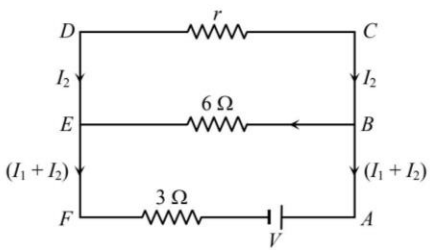
Maximum power consumed,

$P_{max} = \left(\frac{E}{r+r}\right)^2 \times r = \frac{E^2}{4r} = 9$ ...(*i*)

Current, $I = \frac{E}{r+r} = 3, E = 6\ r$ ...(*ii*)

Solving (*i*) and (*ii*), we get $E = 6$ V.

98. **(2)** The equivalent circuit with the distribution of current is shown in Fig.



Using Kirchhoff's second law, in closed circuit ABEFA, we have, $6I_1 + 3(I_1 + I_2) - V = 0$

or $V = 9I_1 + 3I_2$ . . .(*i*)

Using Kirchhoff's second law, in closed circuit BCDEB, we have $rI_2 - 6I_1 = 0$ or $I_1 = \frac{I_2}{6}r$

From (i), $V = 9 \times \frac{I_2}{6}r + 3I_2 = \frac{3}{2}I_2 r + 3I_2 = \frac{3I_2}{2}(r+2)$

or $I_2 = \frac{2V}{3(r+2)}$ Power developed in resistor r,

$P = I_2^2 r = \frac{4V^2}{9(r+2)^2} \times r$

Power developed is maximum, when $(r+2)^2$ is minimum

or $(r+2)^2 = 0$

or $r^2 + 4r + 4 = 0$

or $r^2 - 4r + 4 + 8r = 0$

or $(r-2)^2 + 8r = 0$ or $r = 2\Omega$.

99. **(4)** Given, $\frac{J_1}{J_2} = 2.25$

$\Rightarrow \left(\frac{2E}{2r+R}\right)^2 R = J_1$ and $\left(\frac{2E}{r+2R}\right)^2 R = J_2$

$\therefore \frac{(r+2R)^2}{(2r+R)^2} = \frac{J_1}{J_2} = 2.25$

Or $\frac{2+2R}{2r+R} = 1.5 = \frac{3}{2}$

On solving, we get, $R = 4r = 4 \times 1 = 2\Omega$.

100. **(6)** Heat $= mS\Delta T = i^2Rt$

Length $(L) \Rightarrow$ Resistance $= R$ and mass $= m$

Length $(2L) \Rightarrow$ Resistance $= 2R$ and mass $= 2m$

So $\frac{m_1S_1\Delta T_1}{m_2S_2\Delta T_2} = \frac{i_1^2R_1t_1}{i_2^2r_2t_2}$

$\Rightarrow \frac{mS\Delta T}{2mS\Delta T} = \frac{i_1^2Rt}{i_2^2 2Rt} \Rightarrow i_1 = i_2$

$\Rightarrow \frac{(3E)^2}{12} = \frac{(NE)^2}{2R} \Rightarrow N = 6$

* * *