(1) **(B).** Because as temperature increases, the resistivity increases and hence the relaxation time decreases for conductors $\left(\tau \propto \frac{1}{\rho}\right)$.

(2) **(C).** By using $v_d = \frac{i}{neA}$

$$= \frac{100}{10^{28} \times 1.6 \times 10^{-19} \times \frac{\pi}{4} \times (0.02)^2}$$

$= 2 \times 10^{-4}$ m / sec

(3) **(C).** $\frac{1}{R} = \frac{1}{1} + \frac{1}{1} + \frac{1}{1} = \frac{3}{1} \Rightarrow R = \frac{1}{3}$ohm

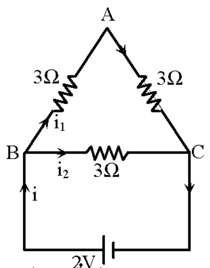
Now such three resistance are joined in series, hence total

$$R = \frac{1}{3} + \frac{1}{3} + \frac{1}{3} = 1 \text{ ohm}$$

(4) **(B).** $R_{AB} = R_1 + \frac{R_2 R_3}{R_2 + R_3} + R_4$

$$= 2 + \frac{4 \times 4}{4+4} + 2 = 6\Omega.$$

(5) **(A).** The circuit can be drawn as follows



Equivalent resistance

$$R = \frac{3 \times (3+3)}{3 + (3+3)} = 2\Omega \;;\quad i = \frac{2}{2} = 1A.$$

$$\text{So, } i_1 = 1 \times \left(\frac{3}{3+6}\right) = \frac{1}{3}A.$$

(6) **(B).** $R_{eq} = R_1 + R_2$

$$\Rightarrow \frac{\rho_{eff.2\ell}}{A} = \frac{\rho_1 \ell}{A} + \frac{\rho_2 \ell}{A} \Rightarrow \rho_{eff.} = \frac{\rho_1 + \rho_2}{2}.$$

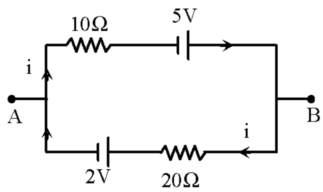
(7) **(B).** By balanced Wheatstone bridge condition

$$\frac{16}{X} = \frac{4}{0.5} \Rightarrow X = \frac{8}{4} = 2\Omega$$

(8) **(B).** Given $R = 6\Omega$. When resistor is cut into two equal parts and connected in parallel, then

$$R_{eq} = \frac{R/2}{2} = \frac{R}{4} = \frac{6}{4} = 1.5\Omega$$

(9) **(A).** Applying Kirchoff's voltage law in the loop



$$-10i + 5 - 20i - 2 = 0 \quad \Rightarrow i = 0.1 \text{ A}$$

(10) **(A).** Potential gradient $x = \frac{e}{(R + R_h + r)} \cdot \frac{R}{L}$

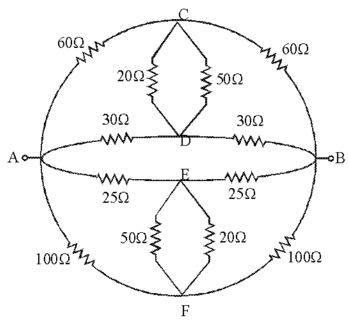
$$\Rightarrow \frac{0.2 \times 10^{-3}}{10^{-2}} = \frac{2}{(R + 490 + 0)} \times \frac{R}{1}$$

$\Rightarrow R = 4.9\ \Omega.$

(11) **(C).** $E_2/E_1 = \ell_2/\ell_1$

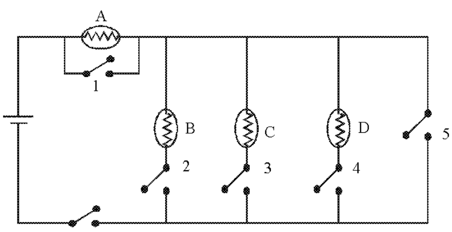
or $E_2 = \ell_2 E_1/\ell_1 = 45 \times 1.018/30 = 1.527$ V

(12) **(B).**



Two balanced Wheatstone bridges each with equivalent resistance 40Ω, therefore total resistance between AB is 20Ω.

(13) **(D).**



Closing switch 1 will short circuit bulb A, closing switch 5 will short circuit BCD so these switches need not be closed.

(14) **(C).** $P = \dfrac{V^2}{R_{eq}}$

$$150 = \frac{(15)^2}{\left(\frac{2R}{R+2}\right)} \Rightarrow R = 6\Omega$$

(15) **(A).** $S = nP$

$$(R_1 + R_2) = n\left(\frac{R_1R_2}{R_1+R_2}\right)$$

$$n = \frac{(R_1+R_2)^2}{R_1R_2} = \frac{R_1}{R_2} + \frac{R_2}{R_1} + 2$$

$$n_{min} = \left(\frac{R_1}{R_2} + \frac{R_2}{R_1}\right)_{min} + 2 = 2 + 2 = 4$$

(16) **(B).** Galvanometer shows zero if potential drop across R is 2V

$$\therefore \left(\frac{R}{500+R}\right)(12V) = 2V \Rightarrow R = 100\Omega$$

(17) **(B).** Given $\rho_B = 2\rho_A$, $r_B = 2r_A$

if $R_A = R_B \Rightarrow \dfrac{\rho_A \ell_A}{\pi r_A^2} = \dfrac{\rho_B \ell_B}{\pi r_B^2}$

$$\Rightarrow \frac{\ell_B}{\ell_A} = \frac{\rho_A}{\rho_B} \cdot \frac{r_B^2}{r_A^2} = \frac{1}{2} \times (2)^2 = 2$$

(18) **(D).** Balanced wheat stone bridge

$R = 10\Omega$

$$\therefore I = \frac{5}{10} = 0.5A$$

(19) **(A).** $\dfrac{X}{Y} = \dfrac{20cm}{80cm} \Rightarrow 4X = Y$

So 4X and Y will balance at 50 cm.

(20) **(A).** $\dfrac{55}{R} = \dfrac{20}{80} \Rightarrow R = 220\Omega$

(21) **(B).** $R = \dfrac{\rho\ell}{A}$ $(\because V = A\ell \text{ const})$.

$V = A\ell$

By differentiation, $0 = \ell\, dA + A\, d\ell$

By differentiation, $dR = \dfrac{\rho\,(A d\ell - \ell dA)}{A^2}$

$$dR = \frac{2\rho d\ell}{A^2} \quad \text{or} \quad \frac{dR}{R} = 2\frac{d\ell}{\ell}$$

So, $\dfrac{dR}{R}\% = 2\dfrac{d\ell}{\ell}\% = 2 \times 0.1\%$

$$\frac{dR}{R}\% = 0.2\%$$

(22) **(D).** $R = \dfrac{V}{i_g} - G = \dfrac{100}{10 \times 10^{-3}} - 25 = 9975\,\Omega$

(23) **(D).** The current through the combination is I and the resistance of the combination is 2R.

(24) **(D).** Here, $R_0 = 99\Omega$, $T_0 = 27°C$

$R_T = 116\Omega$

$\alpha = 1.7 \times 10^{-4} °C^{-1}$

$\therefore R_T = R_0\,[1 + \alpha\,(T - T_0)]$

$$\therefore \frac{R_T}{R_0} - 1 = \alpha\,(T - T_0)$$

$$\Rightarrow \frac{116}{99} - 1 = \alpha\,(T - T_0)$$

$$T - T_0 = \frac{1}{\alpha}\left[\frac{116-99}{99}\right]$$

$$= \frac{17}{99\alpha} = \frac{1}{1.7 \times 10^{-4}} \times \frac{17}{99}$$

$$T - T_0 = \frac{10^5}{99} = 1010.10°C$$

$T = 1010.1 + T_0$

$= 1010.1 + 27 = 1037.1°C$

(25) **(B).** Let dq be the charge which passes in a small interval of time dt. Then

$dq = Idt$

or $dq = (4 + 2t)dt$

On integrating, we get

$$q = \int_2^6 (4+2t)\,dt = [4t+t^2]_2^6 = 48C$$

(26) **(A).** Resistivities of insulators are 10^{18} times greater than metals and more.

(27) **(A).** If there are n cells of emf $\varepsilon_1, ..., \varepsilon_n$ and of internal resistances $r_1,...., r_n$ respectively, connected in parallel, the combination is equivalent to a single cell of emf ε_{eq} and internal resistance r_{eq}, such that

$$\frac{1}{r_{eq}} = \frac{1}{r_1} + ... + \frac{1}{r_n} \text{ and}$$

$$\frac{\varepsilon_{eq}}{r_{eq}} = \frac{\varepsilon_1}{r_1} + ... + \frac{\varepsilon_n}{r_n}$$

In the equation, $\frac{\varepsilon_{eq}}{r_{eq}} = \frac{\varepsilon_1}{r_1} + \frac{\varepsilon_2}{r_2} + ... + \frac{\varepsilon_n}{r_n}$

if the cells are in opposite direction, negative sign is used for the cell emf.

(28) **(B).** Since voltmeter records 5V, it means the equivalent. Resistance of voltmeter and 100 Ω must be 50, because in series grouping if resistances are equal, they share equal potential difference. It conclude that resistance of voltmeter must be 100 Ω.

(29) **(D).** Current through 2Ω, $I_1 = 2I/3$
Heat produced per second,

$$H_1 = I_1^2 \times 2 = \left(\frac{2I}{3}\right)^2 \times 2 = \frac{8I^2}{9}$$

Current through 4Ω, $I_2 = I/3$
Heat produced per second

$$H_2 = I_2^2 \times 4 = \left(\frac{I}{3}\right)^2 \times 4 = \frac{4I^2}{9}$$

Current through 3Ω, = I
Heat produced

$$H_3 = I^2 \times 3 = 3I^2 = \frac{27I^2}{9}$$

$\therefore$ $H_1 : H_2 : H_3 = 8 : 4 : 27.$

(30) **(C).** As the meter bridge is balanced,

$$\frac{R}{S} = \frac{\ell_1}{(100-\ell_1)}$$

or $$R = \frac{S\ell_1}{(100-\ell_1)} = \frac{(100\Omega)\,(2.9\text{cm})}{(100-2.9)\text{ cm}} \approx 3\Omega$$

The accuracy of measuring R can be improved if S and R are of the same order, i.e., S should be changed to 3Ω.

(31) **(B).** The amount of charge crossing the area A in time Δt is given by

$$I\,\Delta t = n\,e\,A\,|v_d|\,\Delta t$$

$$I\,\Delta t = \frac{ne^2A}{m}\tau\,\Delta t\,|E| \qquad ...(1)$$

$$\left(v_d = \frac{eE}{m}\tau\right)$$

Current in terms of current density

$$I = |\mathbf{J}|\,A \qquad ...(2)$$

On comparing Eqs. (1) and (2), we get

$$|\mathbf{J}| = \frac{ne^2}{m}\tau\,|\mathbf{E}|$$

$$\mathbf{J} = \frac{ne^2}{m}\tau\,\mathbf{E} \text{ and } \mathbf{J} = \sigma\,\mathbf{E}$$

Here, $\sigma = \frac{ne^2}{m}\tau$ is conductivity.

(32) **(B).** Since $R = \rho\frac{\ell}{a}$ $\therefore$ $R = \rho\frac{d\ell}{4\pi\ell^2}$

(where ℓ is any radius and $d\ell$ is small element).
Total resistance,

$$R = \frac{\rho}{4\pi}\int_{r_1}^{r_2}\frac{d\ell}{r^2} = \frac{\rho}{4\pi}\left[-\frac{1}{\ell}\right]_{r_1}^{r_2} = \frac{\rho}{4\pi}\left[\frac{1}{r_1} - \frac{1}{r_2}\right]$$

$$R = \left[\frac{r_2 - r_1}{r_1 r_2}\right]\frac{\rho}{4\pi}$$

(33) **(B).** For balanced Wheatstone's bridge

$$\frac{P}{Q} = \frac{R}{S} \qquad .....(1)$$

Power dissipation in resistance R with voltage V is V^2/R.

$$\therefore \quad \frac{P_{P+Q}}{P_{R+S}} = \frac{R+S}{P+Q} \quad \text{..... (2)}$$

From equation (1)

$$\frac{P}{Q}+1 = \frac{R}{S}+1 \Rightarrow \frac{P+Q}{Q} = \frac{R+S}{S}$$

or $\dfrac{R+S}{P+Q} = \dfrac{S}{Q}$

Using eq. (1), we get

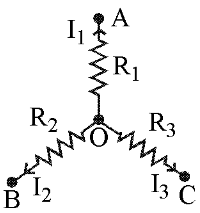
$$\frac{R+S}{P+Q} = \frac{R}{P} \quad \therefore \frac{P_{P+Q}}{P_{R+S}} = \frac{R}{P}$$

(34) (D). Since due to wrong connection of each cell the total emf reduced to 2ε then for wrong connection of three cells the total emf will reduced to (nε - 6ε) whereas the total or equivalent resistance of cell combination will be nr.

(35) (B). Applying junction rule to O

$$-I_1 - I_2 - I_3 = 0$$

i.e., $I_1 + I_2 + I_3 = 0$ ... (i)



Let, V_0 be the potential at point O.
By Ohm's law for resistances R_1, R_2 and R_3 respectively, we get

$(V_0 - V_1) = I_1R_1$; $(V_0 - V_2) = I_2R_2$

and $(V_0 - V_3) = I_3R_3$

or $I_1 = \dfrac{(V_0 - V_1)}{R_1}$; $I_2 = \dfrac{(V_0 - V_2)}{R_2}$

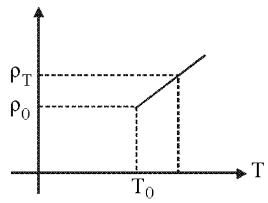
$$I_3 = \frac{(V_0 - V_3)}{R_3}$$

So substituting these values of I_1, I_2 and I_3 in eqn. (1), we get

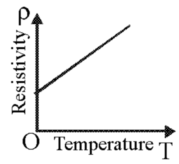
$$V_0\left[\frac{1}{R_1}+\frac{1}{R_2}+\frac{1}{R_3}\right] - \left[\frac{V_1}{R_1}+\frac{V_2}{R_2}+\frac{V_3}{R_3}\right] = 0$$

$$V_0 = \left[\frac{V_1}{R_1}+\frac{V_2}{R_2}+\frac{V_3}{R_3}\right]\left[\frac{1}{R_1}+\frac{1}{R_2}+\frac{1}{R_3}\right]^{-1}$$

(36) (B). The relation of equation $\rho_T = \rho_0\,[1 + \alpha\,(T - T_0)$ implies that a graph of ρ_T plotted against T would be a straight line. At temperatures much lower than 0°C, the graph, however, deviates considerably from a straight line.

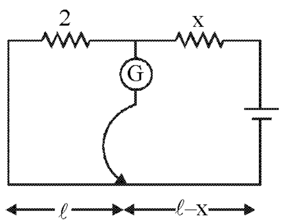


(37) (B). These materials exhibit a very weak dependence of resistivity on temperature. Their resistance values would be changed very little with temperature as shown in figure. Hence these materials are widely used as heating element.



(38) (C). According to Kirchoff's junction rule no current passes through 2Ω resistor.
$\therefore$ i = 0

(39) (A).



$$\frac{2}{x} = \frac{\ell}{100-\ell} \quad \text{......... (1)}$$

$$\frac{x}{2} = \frac{\ell+20}{80-\ell} \quad \text{......... (2)}$$

Solving, eq. (1) and (2), $x = 3\Omega$

(40) (C). $P = V^2/R$

$R_1 = 1\Omega$, $R_2 = (1/2)\,\Omega$, $R_3 = 2\Omega$

(41) (C). $R = \frac{\rho L}{A}$; $R = \frac{\rho L}{tL} = \frac{\rho}{t}$

Independent of L.

(42) (D). Student can use, 100 = 60 + 40

$$\frac{V^2}{R_{100}} = \frac{V^2}{R_{60}} + \frac{V^2}{R_{40}}$$

$$\frac{1}{R_{100}} = \frac{1}{R_{60}} + \frac{1}{R_{40}}$$

But remember it is not correct as in the problem it is mention that resistances are variable.

$$100 = \frac{V^2}{R'_{100}} \Rightarrow \frac{1}{R'_{100}} = \frac{100}{V^2}$$

where R'_{100} is resistance at any temperature corresponds to 100W.

$$600 = \frac{V^2}{R'_{60}} \Rightarrow \frac{1}{R'_{100}} = \frac{60}{V^2}$$

$$40 = \frac{V^2}{R'_{40}} \Rightarrow \frac{1}{R'_{40}} = \frac{40}{V^2}$$

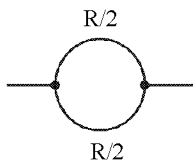
From above equations we can say

$$\frac{1}{R'_{100}} > \frac{1}{R'_{60}} > \frac{1}{R'_{40}}$$

(43) (C). To verify Ohm's law one galvanometer is used as ammeter and other galvanometer is used as voltmeter.

Voltmeter should have high resistance and ammeter should have low resistance as voltmeter is used in parallel and ammeter in series that is in option (C).

(44) (A).



$$R_{eq} = \frac{R_1R_2}{R_1 + R_2} = \frac{\left(\frac{R}{2} \cdot \frac{R}{2}\right)}{\frac{R}{2} + \frac{R}{2}} = \frac{R}{4}$$

(45) (D). Power, $P = i^2R$

where, i = currrent in circuit, R = resistance

$R = P/i^2$

Given P = 1W, i = 5A

$R = 1/(5)^2 = 0.04\ \Omega$