Q.1 When a galvanometer is shunted with a 4Ω resistance, the deflection is reduced to one-fifth. If the galvanometer is further shunted with a 2Ω wire. the further reduction (find the ratio of decrease in current to the previous current) in the deflection will be (the main current remains the same)

(A) (8/13) of the deflection when shunted with 4 Ω only

(B) (5/13) of the deflection when shunted with 4 Ω only

(C) (3/4) of the deflection when shunted with 4 Ω only

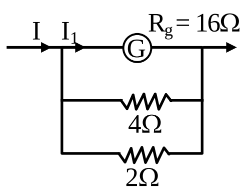
(D)(3/13) of the deflection when shunted with 4 Ω only **[A]**

Sol. Case I

$$R_g \times \frac{I}{5} = \left(I - \frac{I}{5}\right) \times 4$$

$\Rightarrow R_g = 16\ \Omega$

Case II

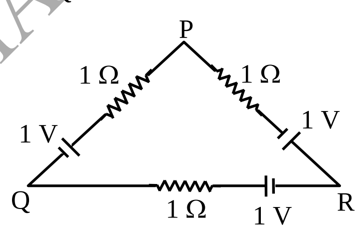


$16\ I_1 = \frac{4 \times 2}{6}\ (I - I_1) \Rightarrow I_1 = I/13$

So decrease in current to previous current

$$= \frac{I/5 - I/13}{I/5} = \frac{8}{13}$$

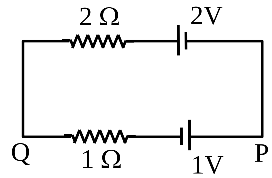
Q.2 Three batteries of emf 1V and internal resistance 1 Ω each are connected as shown. Effective emf of combination between the points PQ is –



(A) Zero (B) 1V (C) 2V (D) $\frac{2}{3}$ V

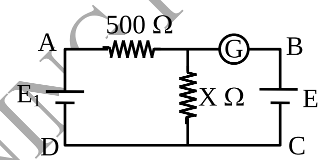
[A]

Sol.



$$E_{net} = \frac{E_1 r_2 - E_2 r_1}{r_1 + r_2} = \frac{2-2}{2+1} = 0$$

Q.3 In an experiment according to set up, when E_1 = 12 volt and internal resistance zero, E = 2 volt. The galvanometer reads zero, then X would be-



(A) 200 (B) 500

(C) 100 (D) 10 **[C]**

Sol. Voltage across X is 2V

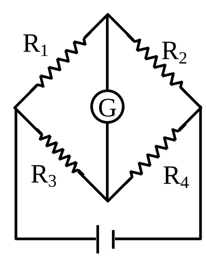
So $\left(\frac{E_1}{500 + X}\right) X = 2$

$\Rightarrow \left(\frac{12}{500 + X}\right) X = 2$

$\Rightarrow$ 12 X = 1000 + 2X

$\Rightarrow$ 10X = 1000 X = 100Ω

Q.4 The resistances in wheat stone's bridge circuit shown in the fig. have different values. The current through, the galvanometer is zero. If all the thermal effects are negligible. The current through the galvanometer will not be zero. When –



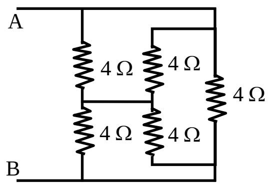
(A) the battery emf is doubled

(B) the battery and galvanometer are interchanged

(C) all resistance in the circuits are doubled

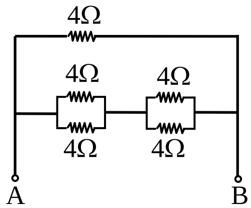
(D) resistance R_1 and R_2 are interchanged **[D]**

Q.5 Equivalent resistance between the points A and B is –



(A) 1Ω (B) 2Ω
(C) 3Ω (D) 4Ω **[B]**

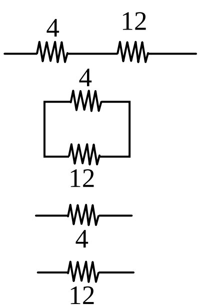
Sol.



Q. 6 By using only two resistors—single, in series or in parallel — you are able to obtain resistances 3, 4, 12 and 16 Ω. What are the separate resistances of the resistors ?

(A) 3 Ω, 4 Ω (B) 4 Ω, 12 Ω
(C) 12 Ω, 16 Ω (D) 3 Ω, 16 Ω **[B]**

Sol.



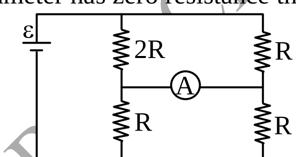
= 16 Ω

= 3 Ω

= 4 Ω

= 12 Ω

Q. 7 If ammeter has zero resistance then –



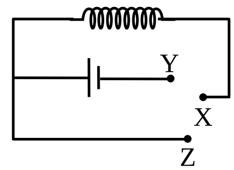
(A) Reading of ammeter is $\frac{\varepsilon}{6R}$

(B) Reading of ammeter is $\frac{\varepsilon}{7R}$

(C) Reading of ammeter is $\frac{\varepsilon}{8R}$

(D) Reading of ammeter is $\frac{\varepsilon}{9R}$ **[B]**

Q.8 In the circuit shown, the coil has inductance and resistance. When X is joined to Y, the time constant is τ during growth of current. When the steady state is reached, rate of production of heat in the coil is "P" joule/sec. X is now joined to Z, and after long time of joining X to Z –



(A) the total heat produced in the coil is Pτ

(B) the total heat produced in the coil is $\frac{1}{2}$ Pτ

(C) the total heat produced in the coil is 2Pτ

(D) the data given is not sufficient to reach a conclusion

Sol.1[B]

Let L and R be the inductance and the resistance of the coil respectively

Let E = e.m.f. of the cell.

τ = Time constant, $I_0 = E/R$

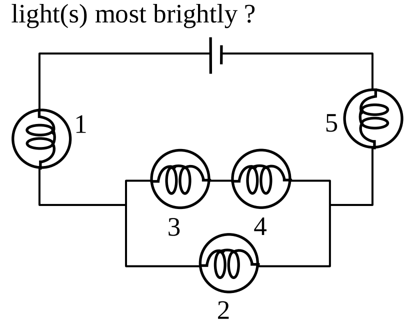
$$P = I_0^2 R = \frac{E^2}{R}$$

$$\text{Energy stored in the coil} = \frac{1}{2} L I_0^2 = \frac{1}{2} L \left(\frac{E^2}{R^2}\right)$$

$$= \frac{1}{2}\left(\frac{L}{R}\right)\left(\frac{E^2}{R}\right) = \frac{1}{2}\tau P$$

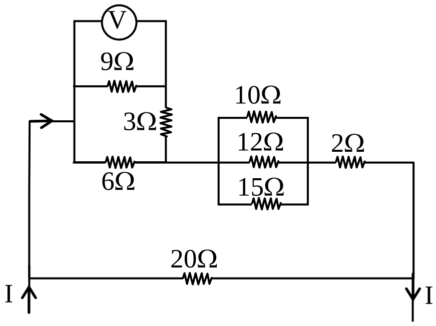
= total heat produced in the coil

Q. 9 All the bulbs below are identical. Which bulb(s) light(s) most brightly ?



(A) 1 only (B) 2 only
(C) 3 and 4 (D) 1 and 5 **[D]**

Q. 10 In the given circuit, the voltmeter reading is 4.5 V. Assuming that the voltmeter is ideal, current through 12Ω resistance is -

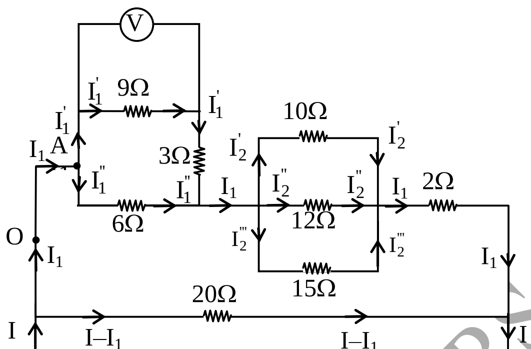


(A) 1 A (B) 0.5 A

(C) 0.25 A (D) 0.1 A

Sol. **[B]**

The voltmeter is ideal, its resistance $R_v \to \infty$ Fig. shows the current distribution in the circuit . Voltmeter will not draw any current.



Potential difference across 9 Ω resistance = 4.5 V (given) Hence, current in 9Ω resistance

$= \frac{4.5}{9} = 0.5$ A $(I = \frac{V}{R})$

i.e., $I_1^{'} = 0.5$ A

The same current $(I_1^{'})$ passes through 3Ω. Obviously, 9 Ω and 3 Ω are in series and their equivalent, i.e., 12Ω is in parallel with 6 Ω between A and B. Dividing the current in the inverse ratio of resistances between A and B,

$$\frac{I_1^{'}}{I_1^{''}} = \frac{6}{12} = \frac{1}{2}$$

$$I_1^{''} = 2I_1^{'} = 2 \times 0.5 = 1 \text{ A}$$

and $I_1 = I_1^{'} + I_1^{''} = 0.5 + 1 = 1.5$ A

at junction C, I_1 divides into three parts. Since the resistances 10Ω, 12Ω, 15 Ω are in parallel between C and D, current will distribute in the inverse ratio of resistances.

$$\therefore\ I_2^{'} : I_2^{''} : I_2^{'''} = \frac{1}{10} : \frac{1}{12} : \frac{1}{15}$$

$= 6 : 5 : 4$

$I_2^{'} = \frac{5}{15} \times 1.5 = 0.5$ amp

So $I_2^{'} = 6k,\ I_2^{''} = 5k,\ I_2^{'''} = 4k$

(k being a constant of proportionality)

and $I_1 = I_2^{'} + I_2^{''} + I_2^{'''} = 15k$

but $I_1 = 1.5$ A

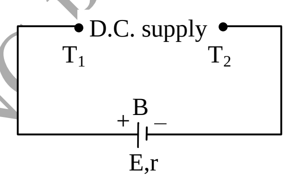
$\therefore$ 15 k = 1.5

or k = 0.1

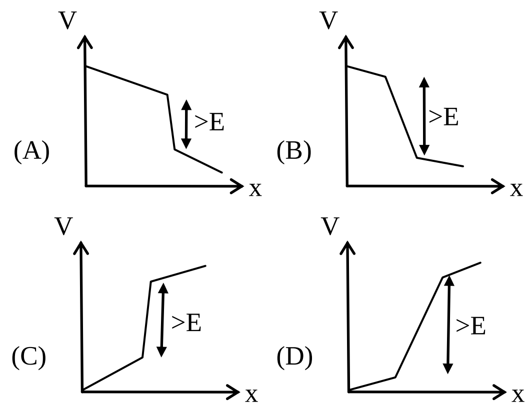
so $I_2^{''} = 5k = 0.5$ A

Thus current through 12Ω resistance is 0.5 A

Q. 11 An accumulator battery B of e.m.f E and internal resistance r being charged from a DC supply whose terminals are T_1 and T_2 The connecting wires have uniform resistance.

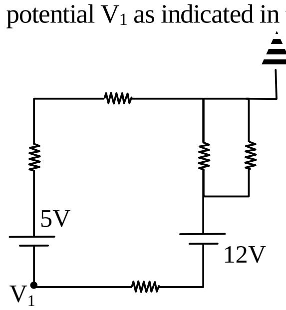


Moving from T_1 to T_2 through B, the potential V is plotted against distance x. The correct curve is -



[A]

Q.12 In the circuit shown, each resistance is 2Ω. The potential V_1 as indicated in the circuit, is equal to –



(A) 11 V (B) – 11V

(C) 9 V (D) – 9 V

Sol. **[D]**

$i = \frac{7V}{7\Omega} = 1$ A

Current flows in anticlockwise direction in the loop. Therefore $0 - 1 \times 2 - 1 \times 2 - 5 = V_1$

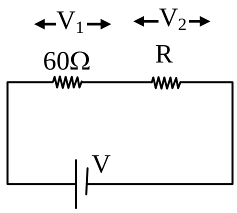
$V_1 = -9V$

Q.13 Two resistances, a 60 ohm and an unknown one are connected to a power source in a series arrangement. This way the power of the unknown resistance is 60 watt. What is the least voltage of the power source ?

(A) 60 Volt (B) 120 Volt

(C) 140 Volt (D) 180 Volt

Sol. **[B]**



$\frac{V_1}{V_2} = \frac{60}{R}$ ....(1)

$V_1 + V_2 = V$ ....(2)

from (1) & (2) $\Rightarrow V_2 = \frac{VR}{60+R}$ ....(3)

$\frac{V_2^2}{R} = 60$ watt ....(4)

from (3) & (4) $V^2R = 60\,(60 + R)^2$

$V^2R = 60(3600 + R^2 + 60R)$

$0 = 60R^2 + 3600\,R - V^2R + 60 \times 3600$

$(3600 - V^2 - 60 \times 60 \times 2)$

$(3600 - V^2 + 60 \times 60 \times 2) > 0$

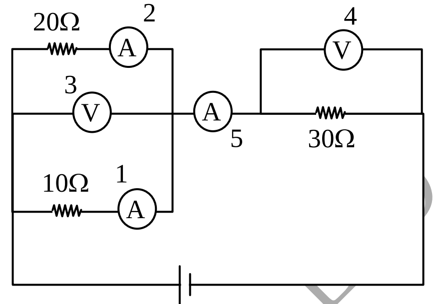
$(3 \times 3600 - V^2)\,(-3600 - V^2) > 0$

$3 \times 3600 - V^2 < 0$

$60 \times 3600 < V^2$

$60 \times \sqrt{3} < V$

Q. 14 If all meters are ideal and reading of voltmeter 3 is 6V. Power supplied by voltage source is -



Voltge source

(A) 10 Watt (B) 38 Watt

(C) 20 Watt (D) 30 Watt

Sol. **[D]**

Current through 20W = $\frac{6}{20}$

current through 10W = $\frac{6}{10}$

Total current supplied by voltage source

$= \frac{6}{10} + \frac{6}{20}$

= 27 Volt

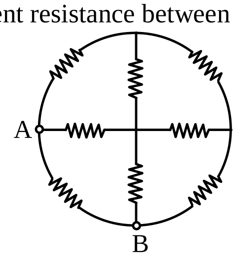
Voltage of battery = 6 + 27 = 33 volt

Power supplied = $\frac{9}{10} \times 33$

= 29.7 or 30 Watt

Potential difference across 30 W = $\left(\frac{6}{10} + \frac{6}{20}\right) \times 30$

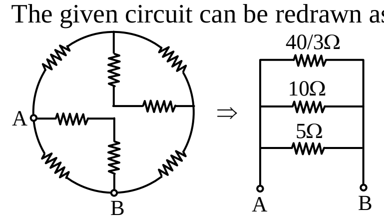
Q.15 Eight resistances each of resistance 5Ω are connected in the circuit as shown in figure. The equivalent resistance between A and B is –



(A) $\frac{8}{3}\Omega$ (B) $\frac{16}{3}\Omega$ (C) $\frac{15}{7}\Omega$ (D) $\frac{19}{2}\Omega$

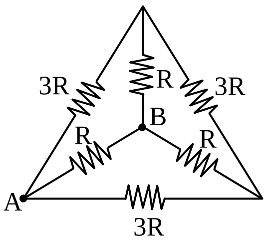
Sol. **[A]**

The given circuit can be redrawn as



$\therefore R_{AB} = \frac{8}{3}\Omega$

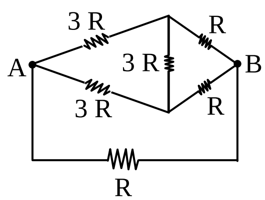
Q. 16 Six resistances are connected as shown here. The effective resistance between points A and B is –



(A) R (B) $\frac{1}{2}$R

(C) $\frac{1}{3}$R (D) $\frac{2}{3}$R **[D]**

Sol. Just disconnect 'R' between A & B unfold the ckt. and reconnect 'R' between A & B



Now it is balanced wheat stone bridge

Q. 17 Two wires A and B of the same material, having radii in the ratio 1 : 2 and carry currents in he ratio 4 : 1. The ratio of drift speed of electrons in A and B is -

(A) 16 : 1 (B) 1 : 16

(C) 1 : 4 (D) 4 : 1 **[A]**

Sol. $I = neAv_d$

$V_d \propto \frac{I}{r^2}$

Q.18 In copper, each copper atom releases one electron. If a current of 1.1 A is flowing in the copper wire of uniform cross-sectional area of diameter 1 mm, then drift velocity of electrons will approximately be-

(Density of copper = 9×10^3 kg /m^3, Atomic weight of copper = 63)

(A) 10.3 mm/s (B) 0.1 mm/s

(C) 0.2 mm/s (D) 0.2 cm/s **[B]**

Q.19 If a copper wire is stretched to make it 0.1% longer, then the percentage change in resistance is approximately -

(A) 0.1% (B) 0.2% (C) 0.4% (D) 0.8%

Sol. **[B]**

$R = \frac{\rho\ell}{A}$, $m = A\,\ell\,d$

$\therefore R = \frac{\rho\ell(\ell d)}{m}$ $\therefore R \propto \ell^2$

$\therefore \frac{\Delta R}{R} \times 100 = 2\frac{\Delta \ell}{\ell} \times 100 = 2 \times 0.1 = 0.2\%$

Q.20 A potential difference V exists between the ends of a metal wire of length ℓ. The drift velocity will be doubled if -

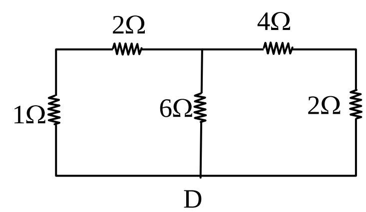
(A) V is doubled

(B) ℓ is doubled

(C) The diameter of the wire is doubled

(D) The temperature of the wire is doubled **[A]**

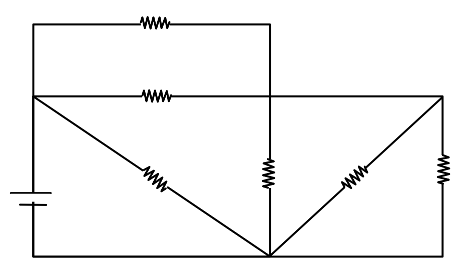
Q.21 Equivalent resistance between point C and D in the combination of resistance shown is –



(A) 3 Ω (B) 1 Ω

(C) 1.5 Ω (D) 0.5 Ω **[C]**

Q.22 In the figure shown each resistor is of 20 Ω and the cell has emf 10 volt with negligible internal resistance. Then rate of joule heating in the circuit is (in watts) -



(A) 100/11 (B) 10000/11

(C) 11 (D) None of these

[C]

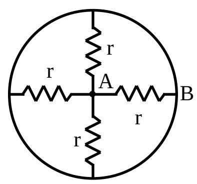
Q.23 The dimensions of a block are 1 cm × 1 cm × 100 cm. If the specific resistance of its material is 2×10^{-7} ohm × metre, then the resistance between the opposite rectangular faces is -

(A) 2×10^{-9} ohm (B) 2×10^{-7} ohm

(C) 2×10^{-5} ohm (D) 2×10^{-3} ohm **[B]**

Sol. $R = \frac{\rho\ell}{A} = \frac{\rho(1\text{cm})}{(1\text{cm} \times 100\text{ cm})}$

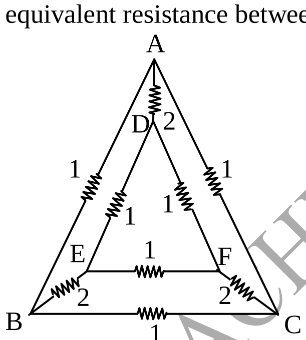
Q.24 The equivalent resistance between point A and B is -



(A) 4 r (B) 2r

(C) r (D) $\frac{r}{4}$ **[D]**

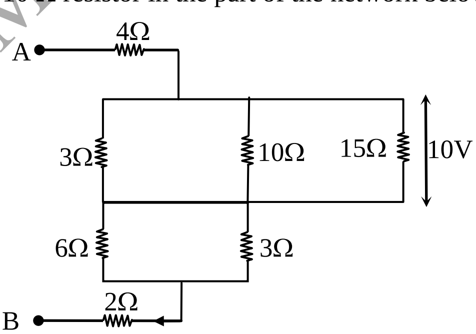
Q.25 A network of nine conductors connects six points A, B, C, D, E and F as shown below. The digits denote resistances in Ω. Find the equivalent resistance between A and D -



(A) 2 Ω (B) 3 Ω

(C) 1 Ω (D) 5 Ω **[C]**

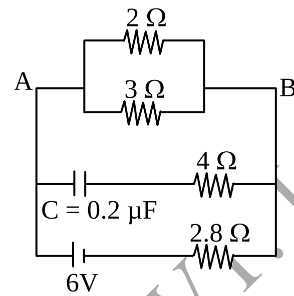
Q.26 Calculate the potential difference between points A and B and current flowing through the 10 Ω resistor in the part of the network below -



(A) 20 V, 2A (B) 50 V, 1A

(B) 40 V, 1A (D) 30 V, 1A **[B]**

Q.27 In Figure the steady state current in 2 Ω resistance is –



(A) 1.5 A (B) 0.9 A

(C) 0.6 A (D) zero **[B]**

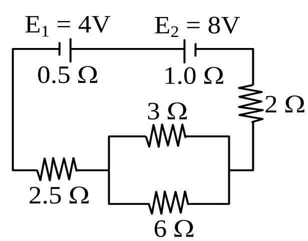
Sol. R–C Ckt so no current in capacitor path.

$I = \frac{6}{1.2 + 2.8} = 1.5$ A

$\therefore I_2 : I_3 = 1/2 : 1/3 = 3.2$

$I_2 = 3/5 \times 1.5 = 0.9$ A

Q. 28 In the circuit shown in the figure below the cells E_1 and E_2 have e.m.f. 4V and 8 V and internal resistance 0.5 ohm and 1.0 ohm respectively. Then the potential difference across cell E_1 and E_2 will be-



(A) 3.75 V, 7.5 V (B) 4.25 V, 7.5 V

(C) 3.75 V, 3.75 V (D) 4.25 V, 4.25 V

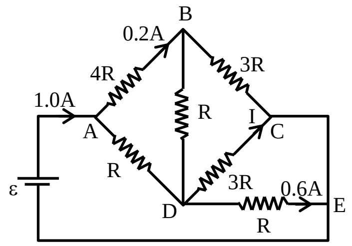
[B]

Sol. $I = \frac{8-4}{8} = 0.5$ A

$V_{8V} = E - Ir = 8 - (0.5)(1) = 7.5$ V

$V_{4V} = E + Ir = 4 + (0.5)(0.5) = 4.25$ V

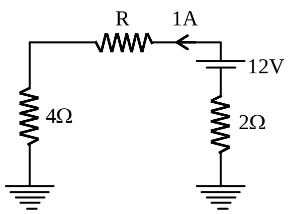
Q.29 The current I in the circuit shown in the figure is -



(A) 0 (B) 0.1 A

(C) 0.4 A (D) 0.2 A **[D]**

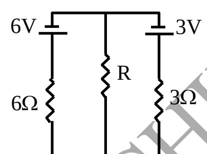
Q.30 In the circuit shown in figure the value of R is-



(A) 8 Ω (B) 6 Ω

(C) 10 Ω (D) 12 Ω **[B]**

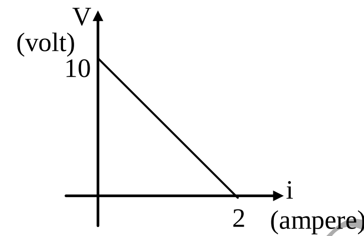
Q.31 In the circuit, the value of R is so chosen that thermal power generated in it is maximum, then value of R is –



(A) 2 Ω (B) 3 Ω

(C) 6 Ω (D) 9 Ω **[A]**

Q.32 A battery of emf E and internal resistance r is connected across a resistance R. Resistance R can be adjusted to any value greater than or equal to zero. A graph is plotted between the current (i) passing through the resistance and potential difference (V) across it. Select the correct alternative(s) -



(A) internal resistance of battery is 5Ω

(B) emf of the battery is 20V

(C) maximum current which can be taken from the battery is 4A

(D) V-i graph can never be a straight line as shown in figure **[A]**

Q.33 four wires of same material and same diameter, have lengths in the ratio 1 : 2 : 3 : 4. These wires are connected in parallel. If a battery is connected across this combination, then the currents in the wires will be in the ratio -

(A) 4 : 3 : 2 : 1 (B) 1 : 2 : 3 : 4

(C) 12 : 6 : 4 : 3 (D) None of these **[C]**

Sol. $I \propto \frac{1}{R} \propto \frac{1}{\ell}$

$I_1 : I_2 : I_3 : I_4 = \frac{1}{1} : \frac{1}{2} : \frac{1}{3} : \frac{1}{4}$

$= 12 : 6 : 4 : 3$

Q.34 A uniform wire of resistance R Ω is divided into 10 parts and all of them are connected in parallel. The equivalent resistance will be -

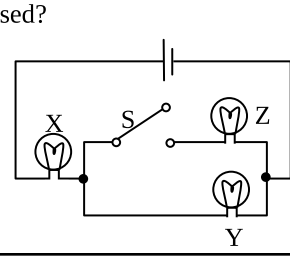
(A) 0.01 R (B) 0.1 R

(C) 10 R (D) 100 R **[A]**

Sol. 10 parallel resistance each of value R/10

$\Rightarrow R_{eq} = \frac{R/10}{10} = 0.01\ R$

Q.35 If X, Y, and Z in figure are identical lamps, which of the following changes to the brightnesses of the lamps occur when switch S is closed?



(A) X stays the same, Y decreases
(B) X increases, Y decreases
(C) X increases, Y stays the same
(D) X decreases, Y increases **[B]**

Q.36 If σ_1, σ_2 and σ_3 are the conductances of three conductors, then their equivalent conductance, when they are joined in series will be -

(A) $\sigma_1 + \sigma_2 + \sigma_3$ (B) $\frac{1}{\sigma_1} + \frac{1}{\sigma_2} + \frac{1}{\sigma_3}$

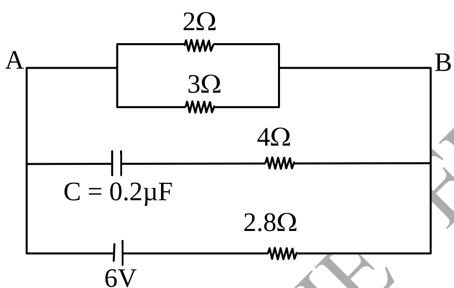
(C) $\frac{\sigma_1\sigma_2\sigma_3}{\sigma_1+\sigma_2+\sigma_3}$ (D) None of these **[D]**

Sol. $R = R_1 + R_2 + R_3$

$$\frac{1}{\sigma} = \frac{1}{\sigma_1} + \frac{1}{\sigma_2} + \frac{1}{\sigma_3}$$

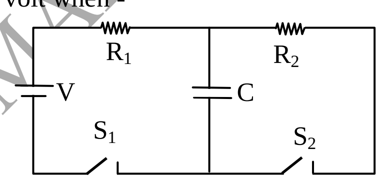
$$\Rightarrow \sigma = \left(\frac{1}{\sigma_1}+\frac{1}{\sigma_2}+\frac{1}{\sigma_3}\right)^{-1}$$

Q.37 In figure, the steady state current in 2Ω resistance is –



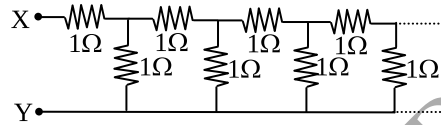
(A) 1.5 A (B) 0.9 A
(C) 0.6 A (D) zero **[B]**

Q.38 A battery of emf V volt, resistance R_1 and R_2, a capacitance C and switches S_1 and S_2 are connected in an electrical circuit as shown in figure. The capacitor C gets fully charged to V volt when -



(A) S_1 and S_2 are both closed
(B) S_1 and S_2 are both open
(C) S_1 closed and S_2 open
(D) S_2 closed and S_1 open **[C]**

Q.39 Figure shows an infinite ladder network of resistance. The equivalent resistance between points X and Y is –



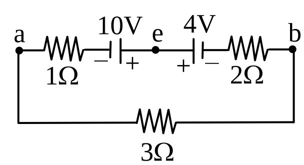
(A) infinite (B) 3 Ω
(C) 8.62 Ω (D) 1.62 Ω **[D]**

Sol. Use approximate method by solving first two blocks only.

$R_{approx} = 5/3 = 1.66\ \Omega$

R_{eq} is slightly less than 1.66 Ω

Q.40 In the circuit diagram show below, the magnitude and direction of the flow of current respectively would be –



(A) 7/3 amp. from a to b via e
(B) 7/3 amp. from b to a via e
(C) 1.0 amp. from b to a via e
(D) 1.0 amp. from a to b via e **[D]**

Sol. $I = \frac{10-4}{1+2+3} = 1$ A (Clockwise so a to b via e)

Q.41 A 1m long metallic wire is broken into two unequal parts A and B. The part A is uniformly extended into another wire C. The length of C is twice the length of A and resistance of C is equal to that of B. The ratio of resistances of parts A and C is -

(A) 4 (B) $\frac{1}{4}$

(C) 2 (D) $\frac{1}{2}$ **[B]**

Sol. let L_A and L_B be length of parts A and B

Then $\frac{R_A}{R_B} = \frac{L_A}{L_B}$ [as cross-section is same]

Now $L_c = 2\,L_A$ and $(\text{volume})_c = (\text{volume})_P$

i.e. $L_c \times A_c = 2\,L_A \times A_c = L_A \times A_A$

where $A_c = A_A$ are cross-sectional area of part C and A.

$\therefore$ $A_c = A_A/2$

$$\therefore \frac{R_A}{R_C} = \frac{\rho L_A / A_A}{\rho L_c / A_c} = \frac{L_A}{L_C} \times \frac{A_C}{A_A}$$

$$= \frac{L_A}{2L_A} \times \frac{A_A/2}{A_A} = \frac{1}{4}$$

Q.42 A resistance R carries a current I. The rate of heat loss to the surroundings is $\lambda\,(T - T_0)$ where λ is a constant. T is the temperature of the resistance and T_0 is the temperature of the atmosphere. If the coefficient of linear expansion is α, the strain in the resistance is –

(A) proportional to the length of the resistance wire

(B) equal to $\frac{\alpha}{\lambda} I^2R$

(C) equal to $\frac{1}{2}\frac{\alpha}{\lambda} I^2R$

(D) equal to $\alpha\lambda$ (IR) **[B]**

Q.43 Resistivity of iron is 1×10^{-7} ohm-metre. The resistance of the given wire of a particular thickness and length is 1 Ω. If the diameter and length of the wire both are doubled, the resistivity will be -

(A) 1×10^{-7} (B) 2×10^{-7}

(C) 4×10^{-7} (D) None of these **[A]**

Sol. Resistivity does not depend on length & cross section area

Q.44 For a metallic wire, the ratio V/I (V = applied potential difference, I = current flowing)-

(A) increases or decreases as the temperature rises, depending upon the metal

(B) decreases as the temperature rises

(C) independent of temperature

(D) increases as the temperature rises **[D]**

Sol. $\frac{V}{I} = R$

and for metals R ↑, on ↑ the temperature.

Q.45 An electric fan and a heater are marked as 100 watt-220 volt and 1000 watt-220 volt respectively. The resistance of heater is -

(A) zero

(B) greater than that of the fan

(C) less than that of the fan

(D) equal to that of the fan **[C]**

Sol. $R_{fan} = \frac{(220)^2}{100}$, $R_{heater} = \frac{(220)^2}{1000}$

$\therefore R_{fan} > R_{heater}$

Q.46 A potential difference of 30 V is applied between the ends of a conductor of length 100 m and resistance 0.5 Ω and uniform area of cross-section. The total linear momentum of free electrons is -

(A) 3.4×10^{-6} kg/s

(B) 4.3×10^{-6} kg/s

(C) 3.4×10^{-8} kg/s

(D) 4.3×10^{-8} kg/s **[C]**

Sol. Current, $I = \frac{V}{R} = \frac{30}{0.5} = 60$ A

Total no. of free e^- s, $N = nA\ell$

and linear momentum of each e^-s, $P = mv_\alpha$

$\therefore$ Total momentum of all free e^-s,

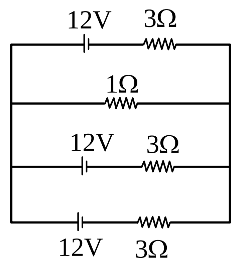
$P = (nA\ell)(m\upsilon_\alpha)$

But $I = neA\upsilon_\alpha$, so $nA\upsilon_\alpha = \frac{I}{e}$

$$\therefore P = \frac{I\ell m}{e} = \frac{60 \times 100 \times 9.1 \times 10^{-31}}{1.6 \times 10^{-19}}$$

3.4×10^{-8} kg/s

Q.47 In adjacent circuit, current flowing in 1Ω resistance will be -



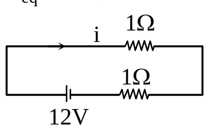
(A) 3A (B) 4A

(C) 5A (D) 6A **[D]**

Sol. All the three given cells are in parallel

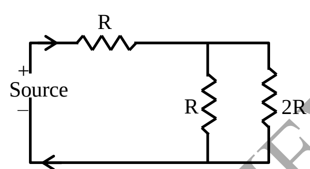
$\therefore\ r_{eq} = \frac{r}{3} = \frac{3}{3} = 1\Omega$

$E_{eq} = 12V$



$i = \frac{12}{1+1} = 6A$

Q.48 The charge supplied by source varies with time t as Q = at – bt^2. The total heat produced in resistor 2R is : (Assume direction of current is not changing)

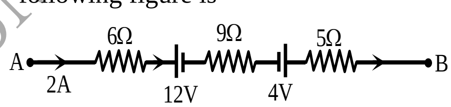


(A) $\frac{a^3R}{6b}$ (B) $\frac{a^3R}{27b}$

(C) $\frac{a^3R}{3b}$ (D) None of these

[B]

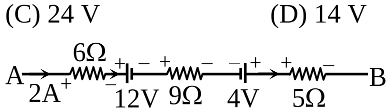
Q.49 The potential difference between A and B in the following figure is -



(A) 32 V (B) 48 V

(C) 24 V (D) 14 V **[B]**

Sol.



$V_A - 2 \times 6 - 12 - 2 \times 9 + 4 - 2 \times 5 = V_B$

$\therefore\ V_A - V_B = 48\ V$

Q.50 At room temperature, copper has free electron density of 8.4 × 10^{28} m^{-3}. The electron drift velocity in a copper conductor of cross-sectional area 10^{-6} m^2 and carrying a current of 5.4 A, will be -

(A) 4 ms^{-1} (B) 0.4 ms^{-1}

(C) 4 cms^{-1} (D) 0.4 mms^{-1} **[D]**

Sol. Use $i = neAv_d$

$\therefore\ v_d = \frac{i}{neA}$

Q.1 A 30 V storage battery is charged from 120 V direct current supply mains with a resistor being connected in series with battery to limit the charging current to 15 amp. If all the heat produced in circuit, could be made available in heating water, the time it would take to bring 1 kg of water from 15ºC to the 100ºC is.......... minute[Neglect the internal resistance of the battery]

Sol. **[0004]**

As the voltage across the charging battery,

$V = E + Ir = 30 + 15 \times 0 = 30V$

So the potential difference across the resistance

$V_R = 120 - 30 = 90$ V

So the power wasted in heating the circuit

$P = VI = 90 \times 15 = 1350$ W

So the energy wasted as heat in time t

$H = P \times t = (1350 \times t)$ joule $= \dfrac{1350}{4.2} \times t$ calorie

Now if this heat changes the temperature of 1 kg of water from 15ºC to 100ºC

$\dfrac{1350\,t}{4.2} = mc\Delta\theta = 1 \times 10^3 \times 1 \times (100 - 15)$

i.e., $t = \dfrac{85 \times 4.2 \times 100}{135} = 264.4$ s $= 4.4$ minute

Q.2 A block of metal is heated directly by dissipating power in the internal resistance of block. Because of temperature rise, the resistance increases exponentially with time and is given by $R(t) = 0.5\,e^{2t}$, where t is in second. The block is connected across a 110 V source and dissipates 7644 J heat energy over a certain period of time. This period of time is...............$\times 10^{-1}$ sec.

Sol. **[0005]**

Let t be the required time. As power is

$P = \dfrac{dU}{dt} = \dfrac{V^2}{R(t)}$

$dU = \dfrac{V^2}{R(t)}\,dt$

$U = \int_0^t \dfrac{V^2}{R(t)}\,dt$

$\dfrac{(110)^2}{0.5}\int_0^t e^{-2t}\,dt$

$= \dfrac{(110)^2}{2 \times 0.5}\left(e^{-2t}\right)_0^t = (110)^2\,(1 - e^{-2t})$J

According to problem,

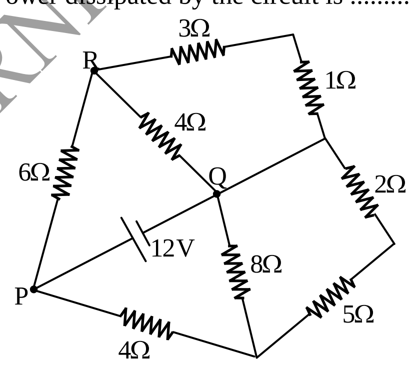
U = 7644J

Thus $1 - e^{-2t} = \dfrac{7644}{(110)^2} = 0.632$

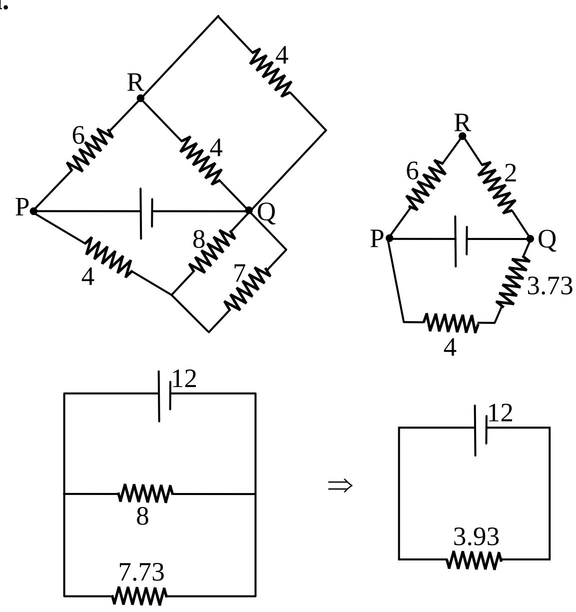
or $e^{-2t} = 0.367$

or $-2\ln e = \ln 0.367$ or $-2t = -1$ or $t = 0.5$ s

Q.3 Power dissipated by the circuit is .... watt.

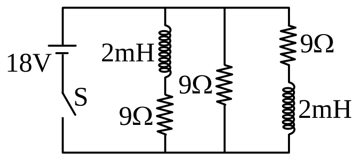


Sol.

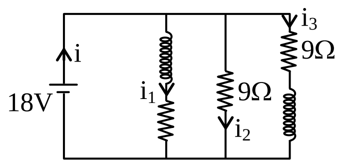


Power dissipated $= \dfrac{(12)^2}{3.93} = 36$ watt

Q.4 Consider the circuit shown in figure. What is the current through the battery just after the switch is closed.



Sol.



Just after closing of switch S

i_1 and i_3

(current through inductor is zero)

$\therefore \quad i = i_2$

$$i_2 = \frac{18}{9} = 2 \text{ amp}$$

Q.5 A 15 amp circuit breaker trips in home when the current through it reaches 15 Amp. What is the minimum number of 100 watt light bulb operated at 120 volts in home that will cause it to the trip.

[0018]

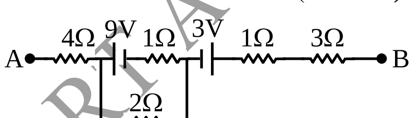
Sol. Current through one bulb $= \frac{100}{120}$

$$15 = N \times \frac{100}{120}$$

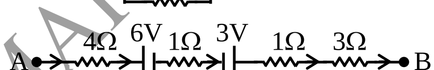
$N = 18$

Where N number of bulbs.

Q.6 Potential difference between the points A and B in the circuit shown is 16 V, then potential difference across 2Ω resistor is …. volt. ($V_A > V_B$)



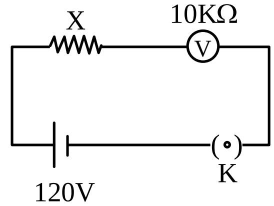
Sol.[6]



$$E_{eq} = \frac{\frac{9}{1}+\frac{0}{2}}{\frac{1}{1}+\frac{1}{2}} = 9 \div \frac{3}{2} = 6 \text{ volt}$$

P.d. across 2Ω = 6 V

Q.7 A D.C. supply of 120 V is connected to a large resistance X. A voltmeter of resistance 10 kΩ placed in series in the circuit reads 20 V. This is an unusual use of voltmeter for measuring very high resistance. The value of X is ………× 10 kΩ (approx).



Sol. [5]

$$I = \frac{20}{10\times10^3} = 20 \times 10^{-4}$$

But $20 \times 10^{-4} = \frac{120}{x+10^4}$

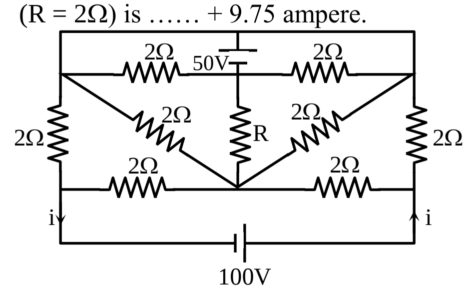
or $20 \times 10^{-4}x + 20 = 120$

$$\therefore \quad x = \left(\frac{120-20}{20}\right)\times10^4$$

$= 5 \times 10^4$ Ω

$= 50$ kΩ

Q.8 Each resistance is of 2Ω. Current in resistance R (R = 2Ω) is …… + 9.75 ampere.



Sol. **[9]**

At y according to Kirchoff's junction law

$$\frac{y-x}{2}+\frac{y-x-100}{2}+\frac{y-50}{2}+\frac{y}{2}+\frac{y-50}{2}=0$$

$5y - 2x = 200$ …(1)

similarly at x

$$i = \frac{50-x}{2}+\frac{y-x}{2} \quad \text{…(2)}$$

at x + 100

$$i = \frac{x+100-50}{2}+\frac{x+100-y}{2} \quad \text{…(3)}$$

we get $y - 2x = 50$ …(4)

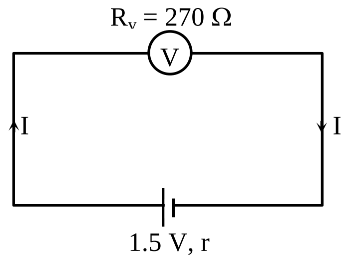
from (1) and (4)

$y = 37.5$ V

So current through R is 18.75 A.

Q.9 As a cell ages, its internal resistance increases. A voltmeter of resistance 270Ω connected across an old dry cell reads 1.44 V. However, a potentiometer at the balance point, gives a voltage measurement of the cell as 1.5 V. Internal resistance of the cell is……… + 5.25 Ω.

Sol. **[6]**



Voltage measured by potentiometer, at the balance point, is the emf. This is because current drawn from the cell, at the balance point is zero.

Hence E = 1.5 V

If a voltmeter of resistance 270Ω is connected across the cell as shown,

$$I = \frac{1.5}{270+r}$$

and voltage measured by the voltmeter

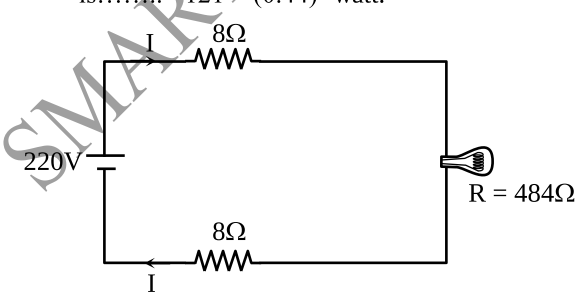
$V = IR_V$ (also V = E – Ir = 1.5 – Ir)

or $V = \left(\frac{1.5}{270+r}\right) 270$ but V = 1.44 V (given)

$\therefore \left(\frac{1.5}{270+r}\right) 270 = 1.44$

or = 11.25Ω

Q.10 Using a long extension cord in which each conductor has a resistance 8Ω, a bulb marked as '100 W, 200 V' is connected to a 220 V dc supply of negligible internal resistance as shown in figure. Power delivered to the bulb is……..× 121 × $(0.44)^2$ watt.



Sol. **[4]**

The circuit can be shown as in the figure. The bulb is marked 100W, 220V.

Hence the resistance of filament of bulb.

$$R = \frac{V^2}{P} = \frac{220 \times 220}{100} = 484\Omega$$

Current in the given circuit

$$I = \frac{220}{484+8+8}$$

= 0.44 A

Power delivered to the bulb

$I^2R_{bulb} = (0.44)^2 (484)$

= 93.7 W

Q.11 A 15 Amp circuit breaker trips in home when the current through it reaches 8 Amp. What is the minimum number of 100 watt light bulb operated at 100 volts in home that will cause it to the trip.

Sol. **[8]**

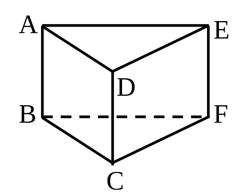
Current through one bulb = $\frac{100}{100}$

$8 = N \times \frac{100}{100}$

N = 8

where N – Number of bulbs.

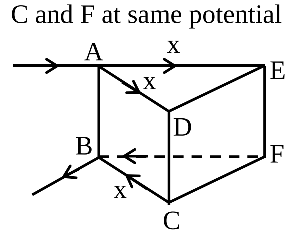
Q.12 Nine wires each of resistance 5Ω are connected to make a prism as shown in figure. Find the equivalent resistance of the arrangement across AB.

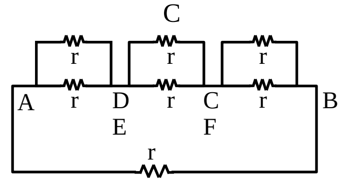


Sol. **[3]**

D and E at same potential

C and F at same potential

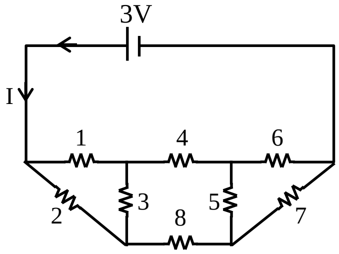




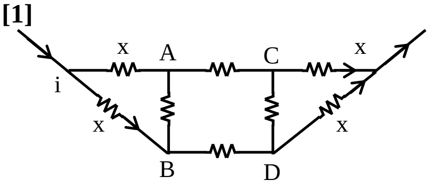
r = 5Ω

$$r_{eq} : = \frac{\frac{3r \times r}{2}}{r + \frac{3r}{2}} = \frac{3r}{5} = 3\ \Omega$$

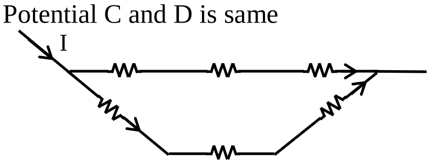
Q.13 Figure show a network of eight resistors numbered 1 to 8, each equal to 2Ω, connected to a 3V battery of negligible internal resistance. The current I in the circuit in ampere is -



Sol. **[1]**



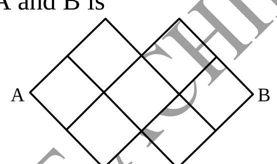
Potential of A and B is same
Potential C and D is same



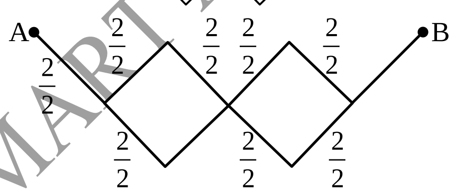
$R_{eq} = \frac{6\times6}{6+6} = 3\Omega$

$I = \frac{3V}{3\Omega} = 1$ amp

Q.14 In the shown wire frame, each side of a square (the smallest square) has a resistance 2Ω. The equivalent resistance of the circuit between the points A and B is



Sol.[4]



$= R_{eq} = 1 + 1 + 1 + 1 = 4\Omega$

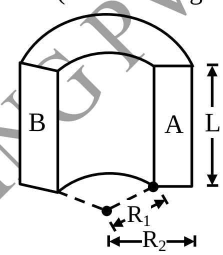
Q.15 Two long parallel wires are located in a poorly conducting medium with resistivity ρ. The distance between the axes of the wires is equal to ℓ, the cross-section radius of each wire equals a. In the case a << ℓ find.

(a) the current density at the point equally removed from the axes of the wires by a distance r if the potential difference between the wires is equal to V ;

(b) the electric resistance of the medium per unit length of the wires.

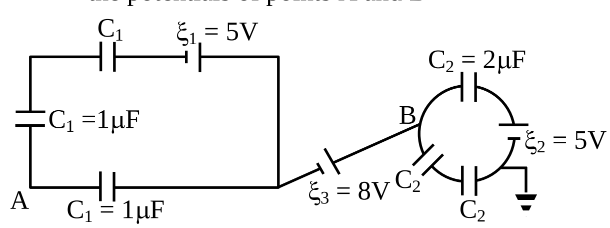
Sol. (a) $j = \frac{\ell V}{2\rho r^2 \ell n\left(\frac{\ell}{a}\right)}$ (b) $R_1 = \frac{\rho}{\pi}\ell n\left(\frac{\ell}{a}\right)$

Q.16 A resistor is formed in the shape of a hollow quarter cylinder from a material of resistivity ρ. The inner and outer radii of the cylinder is R_1 and R_2. Find the resistance of this resistor between faces A and B (Shown in figure.)



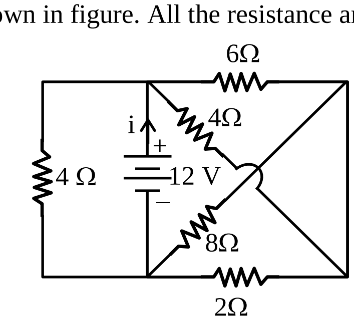
Sol. $\frac{\rho\pi}{2L\ell n\frac{R_2}{R_1}}$

Q.17 In the circuit shown in figure, cells are ideal. Find the potentials of points A and B



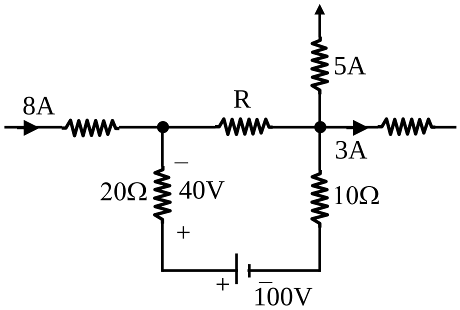
Sol. –8V, $\frac{10}{3}$V

Q.18 Compute the value of battery current in the circuit shown in figure. All the resistance are in ohm.



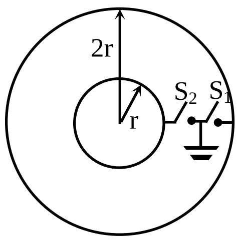
Sol. 6A

Q.19 In the circuit shown in figure, find the value of unknown resistor R.



Sol. 4Ω

Q.20 There are two concentric spherical shells of radii r and 2r. Initially a charge Q is given to the inner shell. Now, switch S_1 is closed and opened then S_2 is closed and opened and the process is repeated n times for both the keys alternatively. Find the final potential difference between the shells.



Sol. $\frac{1}{2^{n+1}}\left[\frac{Q}{4\pi\varepsilon_0 r}\right]$