17

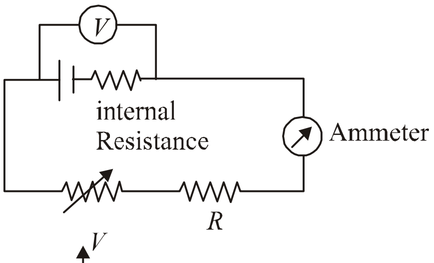
Current Electricity

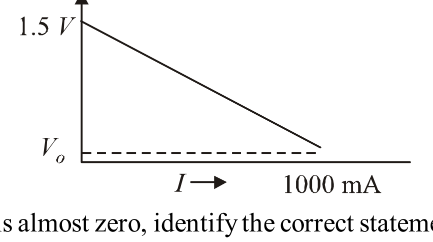
TOPIC 1 Electric Current, Drift of Electrons, Ohm's Law, Resistance and Resistivity

1. A circuit to verify Ohm's law uses ammeter and voltmeter in series or parallel connected correctly to the resistor. In the circuit : **[Sep. 06, 2020 (II)]**
(a) ammeter is always used in parallel and voltmeter is series
(b) Both ammeter and voltmeter must be connected in parallel
(c) ammeter is always connected in series and voltmeter in parallel
(d) Both, ammeter and voltmeter must be connected in series

2. Consider four conducting materials copper, tungsten, mercury and aluminium with resistivity ρ_C, ρ_T, ρ_M and ρ_A respectively. Then : **[Sep. 02, 2020 (I)]**
(a) $\rho_C > \rho_A > \rho_T$ (b) $\rho_M > \rho_A > \rho_C$
(c) $\rho_A > \rho_T > \rho_C$ (d) $\rho_A > \rho_M > \rho_C$

3. To verify Ohm's law, a student connects the voltmeter across the battery as, shown in the figure. The measured voltage is plotted as a function of the current, and the following graph is obtained : **[12 Apr. 2019 I]**

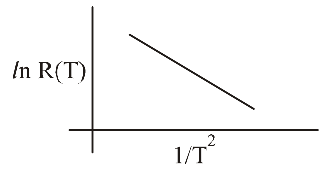




If V_o is almost zero, identify the correct statement:
(a) The emf of the battery is 1.5 V and its internal resistance is 1.5 Ω
(b) The value of the resistance R is 1.5 Ω
(c) The potential difference across the battery is 1.5 V when it sends a current of 1000 mA
(d) The emf of the battery is 1.5 V and the value of R is 1.5 Ω

4. A current of 5 A passes through a copper conductor (resistivity) = $1.7\times10^{-8}\Omega$m) of radius of cross-section 5 mm. Find the mobility of the charges if their drift velocity is 1.1×10^{-3} m/s. **[10 Apr. 2019 I]**
(a) 1.8m^2/Vs (b) 1.5 m^2/Vs
(c) 1.3 m^2/Vs (d) 1.0m^2/Vs

5. In an experiment, the resistance of a material is plotted as a function of temperature (in some range). As shown in the figure, it is a straight line. **[10 Apr. 2019 I]**



One may canclude that:
(a) $R(T)=\dfrac{R_0}{T^2}$ (b) $R(T)=R_0e^{-T_0^2/T^2}$
(c) $R(T)=R_0e^{-T^2/T_0^2}$ (d) $R(T)=R_0e^{T^2/T_0^2}$

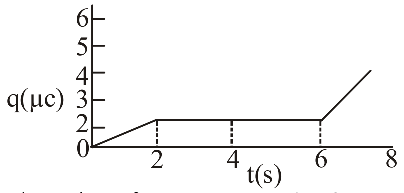
6. Space between two concentric conducting spheres of radii a and b $(b > a)$ is filled with a medium of resistivity ρ. The resistance between the two spheres will be : **[10 Apr. 2019 II]**
(a) $\dfrac{\rho}{4\pi}\left(\dfrac{1}{a}-\dfrac{1}{b}\right)$ (b) $\dfrac{\rho}{2\pi}\left(\dfrac{1}{a}-\dfrac{1}{b}\right)$
(c) $\dfrac{\rho}{2\pi}\left(\dfrac{1}{a}+\dfrac{1}{b}\right)$ (d) $\dfrac{\rho}{4\pi}\left(\dfrac{1}{a}+\dfrac{1}{b}\right)$

7. In a conductor, if the number of conduction electrons per unit volume is 8.5×10^{28} m^{-3} and mean free time is 25 *fs* (femto second), it's approximate resistivity is: ($m_e = 9.1\times10^{-31}$ kg) **[9 Apr. 2019 II]**
(a) 10^{-6} Ω m (b) 10^{-7} Ωm
(c) 10^{-8} Ωm (d) 10^{-5} Ωm

8. A 200 Ω resistor has a certain color code. If one replaces the red color by green in the code, the new resistance will be : **[8 April 2019 I]**

(a) 100 Ω (b) 400 Ω (c) 300 Ω (d) 500 Ω

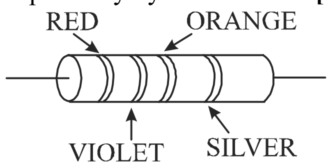
9. The charge on a capacitor plate in a circuit, as a function of time, is shown in the figure: **[12 Jan. 2019 II]**



What is the value of current at t = 4 s ?

(a) Zero (b) 3 μA (c) 2 μA (d) 1.5 μA

10. A resistance is shown in the figure. Its value and tolerance are given respectively by: **[9 Jan. 2019 I]**



(a) 270 Ω, 10% (b) 27 kΩ, 10%

(c) 27 kΩ, 20% (d) 270 Ω, 5%

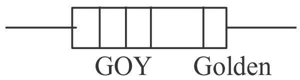
11. Drift speed of electrons, when 1.5 A of current flows in a copper wire of cross section 5 mm^2, is v. If the electron density in copper is $9 \times 10^{28}/m^3$ the value of v in mm/s close to (Take charge of electron to be = 1.6×10^{-19}C) **[9 Jan. 2019 I]**

(a) 0.02 (b) 3 (c) 2 (d) 0.2

12. A copper wire is stretched to make it 0.5% longer. The percentage change in its electrical resistance if its volume remains unchanged is: **[9 Jan. 2019 I]**

(a) 2.0% (b) 2.5% (c) 1.0% (d) 0.5%

13. A carbon resistance has following colour code. What is the value of the resistance? **[9 Jan. 2019 II]**



(a) 530 kΩ ± 5% (b) 5.3 kΩ ± 5%

(c) 6.4 MΩ ± 5% (d) 64 MΩ ± 10%

14. A heating element has a resistance of 100Ω at room temperature. When it is connected to a supply of 220 V, a steady current of 2 A passes in it and temperature is 500°C more than room temperature. What is the temperature coefficient of resistance of the heating element? **[Online April 16, 2018]**

(a) 1×10^{-4}°C^{-1} (b) 5×10^{-4}°C^{-1}

(c) 2×10^{-4}°C^{-1} (d) 0.5×10^{-4}°C^{-1}

15. A copper rod of cross-sectional area A carries a uniform current I through it. At temperature T, if the volume charge density of the rod is ρ, how long will the charges take to travel a distance d ? **[Online April 15, 2018]**

(a) $\frac{2\rho dA}{IT}$ (b) $\frac{2\rho dA}{I}$ (c) $\frac{\rho dA}{I}$ (d) $\frac{\rho dA}{IT}$

16. A uniform wire of length l and radius r has a resistance of 100 Ω. It is recast into a wire of radius $\frac{r}{2}$. The resistance of new wire will be : **[Online April 9, 2017]**

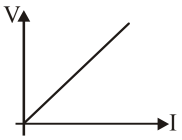
(a) 1600 Ω (b) 400 Ω (c) 200 Ω (d) 100 Ω

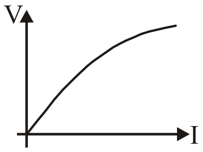
17. When 5V potential difference is applied across a wire of length 0.1 m, the drift speed of electrons is 2.5×10^{-4} ms^{-1}. If the electron density in the wire is 8×10^{28} m^{-3}, the resistivity of the material is close to : **[2015]**

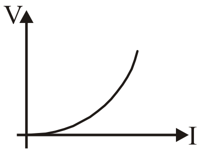
(a) 1.6×10^{-6} Ωm (b) 1.6×10^{-5} Ωm

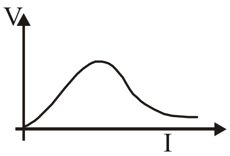
(c) 1.6×10^{-8} Ωm (d) 1.6×10^{-7} Ωm

18. Suppose the drift velocity v_d in a material varied with the applied electric field E as $v_d \propto \sqrt{E}$. Then V – I graph for a wire made of such a material is best given by : **[Online April 10, 2015]**

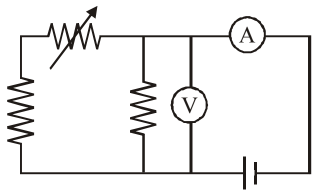
(a) 

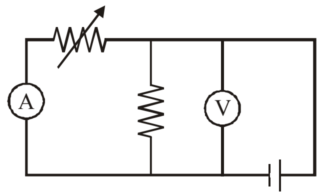
(b) 

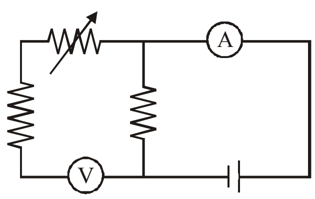
(c) 

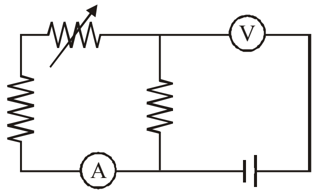
(d) 

19. Correct set up to verify Ohm's law is : **[Online April 23, 2013]**

(a) 

(b) 

(c) 

(d) 

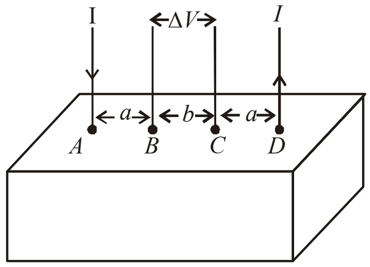
20. The resistance of a wire is R. It is bent at the middle by 180° and both the ends are twisted together to make a shorter wire. The resistance of the new wire is **[Online May 26, 2012]**
(a) $2R$ (b) $R/2$ (c) $R/4$ (d) $R/8$

21. If a wire is stretched to make it 0.1% longer, its resistance will : **[2011]**
(a) increase by 0.2% (b) decrease by 0.2%
(c) decrease by 0.05% (d) increase by 0.05%

DIRECTIONS : Question No. 22 and 23 are based on the following paragraph.

Consider a block of conducting material of resistivity 'ρ' shown in the figure. Current 'I' enters at 'A' and leaves from 'D'. We apply superposition principle to find voltage 'ΔV' developed between 'B' and 'C'. The calculation is done in the following steps:

(i) Take current 'I' entering from 'A' and assume it to spread over a hemispherical surface in the block.
(ii) Calculate field E(r) at distance 'r' from A by using Ohm's law $E = \rho j$, where j is the current per unit area at 'r'.
(iii) From the 'r' dependence of E(r), obtain the potential V(r) at r.
(iv) Repeat (i), (ii) and (iii) for current 'I' leaving 'D' and superpose results for 'A' and 'D'.



22. ΔV measured between B and C is **[2008]**
(a) $\frac{\rho I}{\pi a} - \frac{\rho I}{\pi(a+b)}$ (b) $\frac{\rho I}{a} - \frac{\rho I}{(a+b)}$
(c) $\frac{\rho I}{2\pi a} - \frac{\rho I}{2\pi(a+b)}$ (d) $\frac{\rho I}{2\pi(a-b)}$

23. For current entering at A, the electric field at a distance 'r' from A is **[2008]**
(a) $\frac{\rho I}{8\pi r^2}$ (b) $\frac{\rho I}{r^2}$ (c) $\frac{\rho I}{2\pi r^2}$ (d) $\frac{\rho I}{4\pi r^2}$

24. The resistance of a wire is 5 ohm at 50°C and 6 ohm at 100°C. The resistance of the wire at 0°C will be **[2007]**
(a) 3 ohm (b) 2 ohm (c) 1 ohm (d) 4 ohm

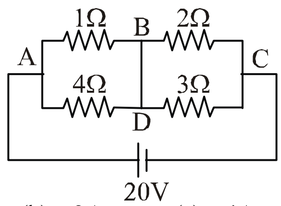
25. A material 'B' has twice the specific resistance of 'A'. A circular wire made of 'B' has twice the diameter of a wire made of 'A'. then for the two wires to have the same resistance, the ratio l_B/l_A of their respective lengths must be **[2006]**
(a) 1 (b) $\frac{1}{2}$ (c) $\frac{1}{4}$ (d) 2

26. An electric current is passed through a circuit containing two wires of the same material, connected in parallel. If the lengths and radii are in the ratio of $\frac{4}{3}$ and $\frac{2}{3}$, then the ratio of the current passing through the wires will be **[2004]**
(a) 8/9 (b) 1/3 (c) 3 (d) 2

27. The length of a given cylindrical wire is increased by 100%. Due to the consequent decrease in diameter the change in the resistance of the wire will be **[2003]**
(a) 200% (b) 100% (c) 50% (d) 300%

TOPIC 2 Combination of Resistances

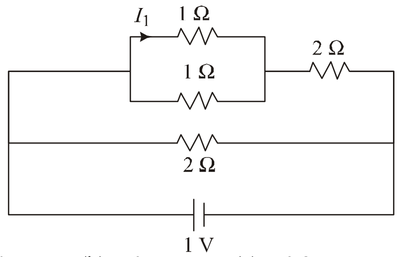
28. In the given circuit diagram, a wire is joining points B and D. The current in this wire is: **[9 Jan. 2020 I]**



(a) 0.4A (b) 2A (c) 4A (d) zero

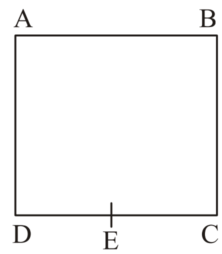
29. The series combination of two batteries, both of the same emf 10 V, but different internal resistance of 20 Ω and 5 Ω, is connected to the parallel combination of two resistors 30 Ω and R Ω. The voltage difference across the battery of internal resistance 20 Ω is zero, the value of R (in Ω) is _________. **[NA. 8 Jan. 2020 II]**

30. The current I_1 (in A) flowing through 1 Ω resistor in the following circuit is: **[7 Jan. 2020 I]**



(a) 0.4 (b) 0.5 (c) 0.2 (d) 0.25

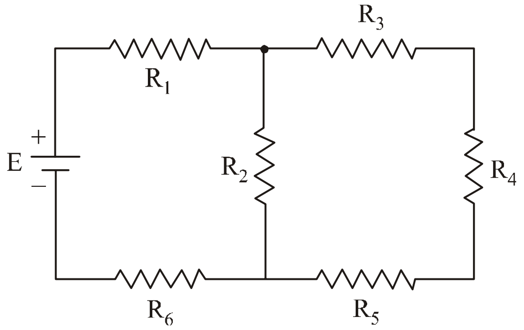
31. A wire of resistance R is bent to form a square ABCD as shown in the figure. The effective resistance between E and C is: (E is mid-point of arm CD) **[9 April 2019 I]**



(a) R (b) $\frac{7}{64}$R (c) $\frac{3}{4}$R (d) $\frac{1}{16}$R

32. A metal wire of resistance 3 Ω is elongated to make a uniform wire of double its previous length. This new wire is now bent and the ends joined to make a circle. If two points on the circle make an angle 60° at the centre, the equivalent resistance between these two points will be: **[9 Apr. 2019 II]**
(a) $\frac{12}{5}\Omega$ (b) $\frac{5}{2}\Omega$ (c) $\frac{5}{3}\Omega$ (d) $\frac{7}{2}\Omega$

33. In the figure shown, what is the current (in Ampere) drawn from the battery? You are given : **[8 Apr. 2019 II]**
$R_1 = 15\ \Omega$, $R_2 = 10\ \Omega$, $R_3 = 20\ \Omega$, $R_4 = 5\ \Omega$, $R_5 = 25\ \Omega$, $R_6 = 30\ \Omega$, $E = 15$ V

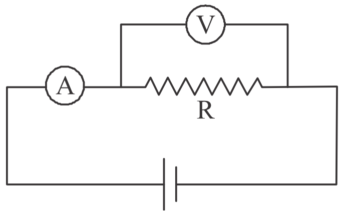


(a) 13/24 (b) 7/18 (c) 9/32 (d) 20/3

34. A uniform metallic wire has a resistance of 18 Ω and is bent into an equilateral triangle. Then, the resistance between any two vertices of the triangle is: **[10 Jan. 2019 I]**

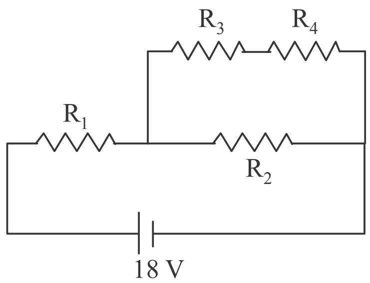
(a) 4 Ω (b) 8 Ω (c) 12 W (d) 2 W

35. The actual value of resistance R, shown in the figure is 30 Ω. This is measured in an experiment as shown using the standard formula $R = \frac{V}{I}$, where V and I are the reading of the voltmeter and ammeter, respectively. If the measured value of R is 5% less, then the internal resistance of the voltmeter is: **[10 Jan. 2019 II]**



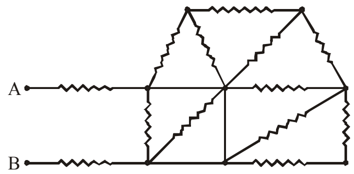
(a) 600 Ω (b) 570 Ω (c) 35 W (d) 350 W

36. In the given circuit the internal resistance of the 18 V cell is negligible. If $R_1 = 400\Omega$, $R_3 = 100\ \Omega$ and $R_4 = 500\ \Omega$ and the reading of an ideal voltmeter across R_4 is 5 V, then the value of R_2 will be: **[9 Jan. 2019 II]**



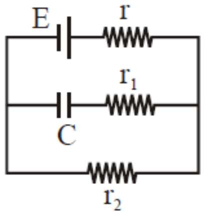
(a) 300 W (b) 450 W
(c) 550 W (d) 230 W

37. In the given circuit all resistances are of value *R* ohm each. The equivalent resistance between *A* and *B* is : **[Online April 15, 2018]**



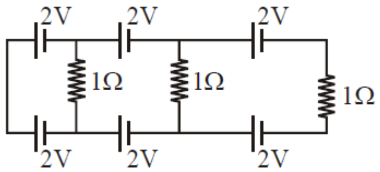
(a) $2R$ (b) $\frac{5R}{2}$ (c) $\frac{5R}{3}$ (d) $3R$

38. In the given circuit diagram when the current reaches steady state in the circuit, the charge on the capacitor of capacitance C will be : **[2017]**



(a) $CE\frac{r_2}{(r+r_2)}$
(b) $CE\frac{r_1}{(r_1+r)}$
(c) CE
(d) $CE\frac{r_1}{(r_2+r)}$

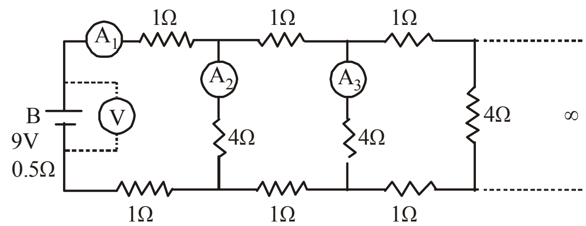
39.



In the above circuit the current in each resistance is **[2017]**

(a) 0.5A (b) 0 A (c) 1 A (d) 0.25 A

40.

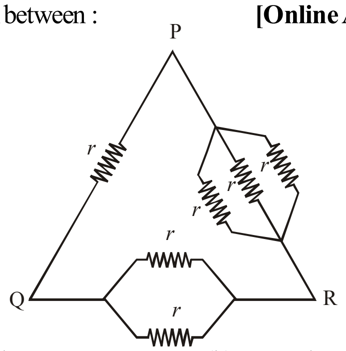


A 9 V battery with internal resistance of 0.5 Ω is connected across an infinite network as shown in the figure. All ammeters A_1, A_2, A_3 and voltmeter V are ideal.

Choose correct statement. **[Online April 8, 2017]**

(a) Reading of A_1 is 2 A (b) Reading of A_1 is 18 A
(c) Reading of V is 9 V (d) Reading of V is 7 V

41. Six equal resistances are connected between points P, Q and R as shown in figure. Then net resistance will be maximum between : **[Online April 25, 2013]**



(a) P and R (b) P and Q
(c) Q and R (d) Any two points

42. A letter 'A' is constructed of a uniform wire with resistance 1.0 Ω per cm, The sides of the letter are 20 cm and the cross piece in the middle is 10 cm long. The apex angle is 60 . The resistance between the ends of the legs is close to: **[Online April 9, 2013]**

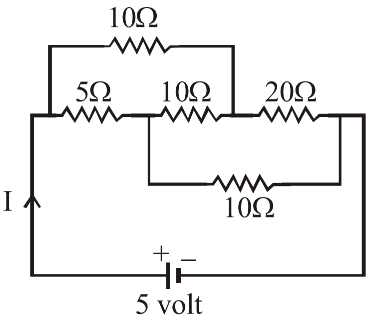
(a) 50.0 Ω (b) 10 Ω (c) 36.7 Ω (d) 26.7 Ω

43. Two conductors have the same resistance at 0°C but their temperature coefficients of resistance are α_1 and α_2. The respective temperature coefficients of their series and parallel combinations are nearly **[2010]**

(a) $\frac{\alpha_1+\alpha_2}{2}, \alpha_1+\alpha_2$ (b) $\alpha_1+\alpha_2, \frac{\alpha_1+\alpha_2}{2}$

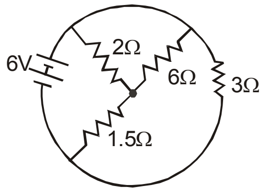
(c) $\alpha_1+\alpha_2, \frac{\alpha_1\alpha_2}{\alpha_1+\alpha_2}$ (d) $\frac{\alpha_1+\alpha_2}{2}, \frac{\alpha_1+\alpha_2}{2}$

44. The current I drawn from the 5 volt source will be **[2006]**



(a) 0.33 A (b) 0.5 A (c) 0.67 A (d) 0.17 A

45. The total current supplied to the circuit by the battery is **[2004]**

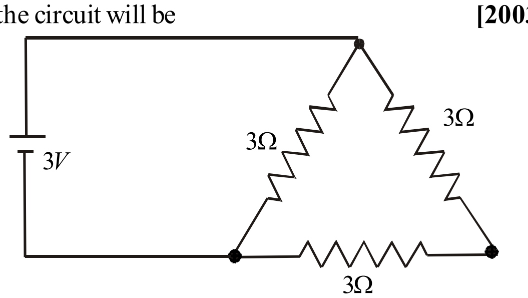


(a) 4 A (b) 2 A (c) 1 A (d) 6 A

46. The resistance of the series combination of two resistances is S. when they are joined in parallel the total resistance is P. If $S = nP$ then the minimum possible value of n is **[2004]**

(a) 2 (b) 3 (c) 4 (d) 1

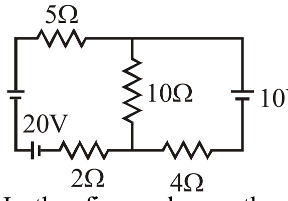
47. A 3 volt battery with negligible internal resistance is connected in a circuit as shown in the figure. The current I, in the circuit will be **[2003]**



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

TOPIC 3 Kirchhoff's Laws, Cells, Thermo e.m.f. & Electrolysis

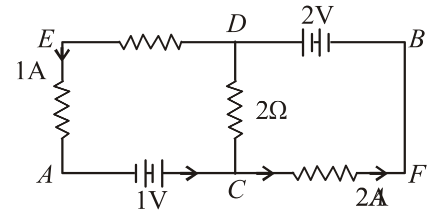
48.



In the figure shown, the current in the 10 V battery is close to : **[Sep. 06, 2020 (II)]**

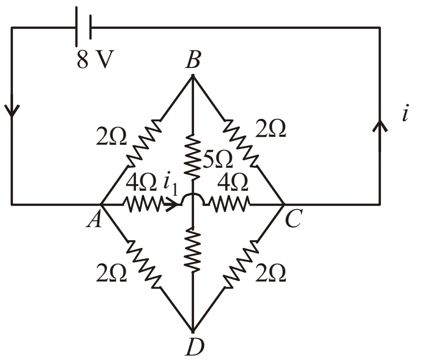
(a) 0.71 A from positive to negative terminal
(b) 0.42 A from positive to negative terminal
(c) 0.21 A from positive to negative terminal
(d) 0.36 A from negative to positive terminal

49. In the circuit, given in the figure currents in different branches and value of one resistor are shown. Then potential at point B with respect to the point A is : **[Sep. 05, 2020 (II)]**



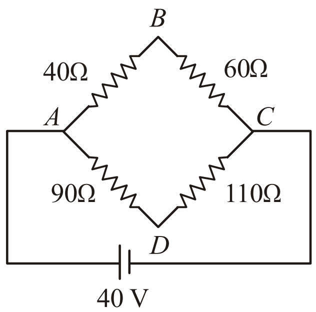
(a) +2 V (b) –2 V (c) –1 V (d) +1 V

50. The value of current i_1 flowing from A to C in the circuit diagram is : **[Sep. 04, 2020 (II)]**



(a) 2 A (b) 4 A (c) 1 A (d) 5 A

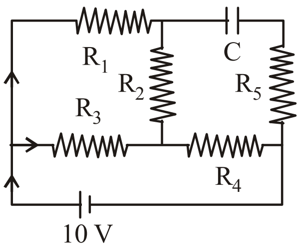
51.



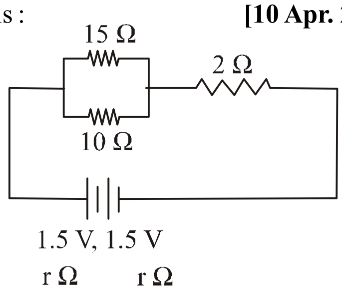
Four resistances 40 Ω, 60 Ω, 90 Ω and 110 Ω make the arms of a quadrilateral $ABCD$. Across AC is a battery of emf 40 V and internal resistance negligible. The potential difference across BD in V is __________.

[NA. Sep. 04, 2020 (II)]

52. An ideal cell of emf 10 V is connected in circuit shown in figure. Each resistance is 2 Ω. The potential difference (in V) across the capacitor when it is fully charged is __________. **[Sep. 02, 2020 (II)]**

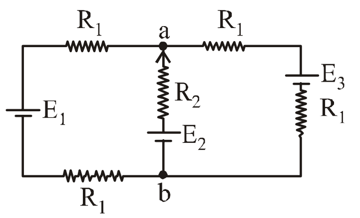


53. In the given circuit, an ideal voltmeter connected across the 10 Ω resistance reads 2V. The internal resistance r, of each cell is : **[10 Apr. 2019 I]**



(a) 1 Ω (b) 0.5 Ω (c) 1.5 Ω (d) 0 Ω

54. For the circuit shown, with $R_1 = 1.0\,\Omega$, $R_2 = 2.0\,\Omega$, $E_1 = 2\,V$ and $E_2 = E_3 = 4$ V, the potential difference between the points '*a*' and '*b*' is approximately (in V) : **[8 April 2019 I]**

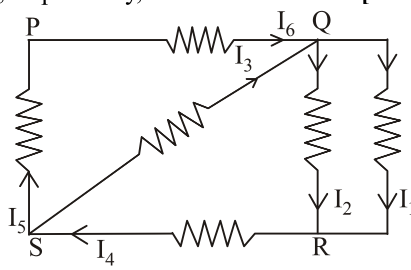


(a) 2.7 (b) 2.3 (c) 3.7 (d) 3.3

55. A cell of internal resistance *r* drives current through an external resistance R. The power delivered by the cell to the external resistance will be maximum when : **[8 Apr. 2019 II]**

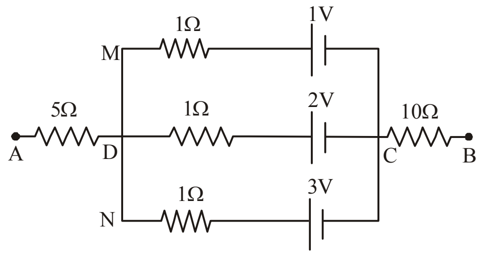
(a) $R = 0.001\,r$ (b) $R = 1000\,r$
(c) $R = 2r$ (d) $R = r$

56. In the given circuit diagram, the currents, $I_1 = -0.3$ A, $I_4 = 0.8$ A and $I_5 = 0.4$ A, are flowing as shown. The currents I_2, I_3 and I_6, respectively, are : **[12 Jan. 2019 II]**



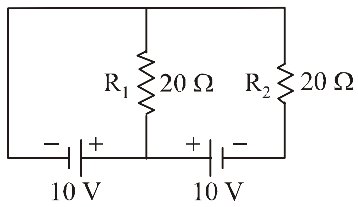
(a) 1.1 A, – 0.4 A, 0.4 A (b) 1.1 A, 0.4 A, 0.4 A
(c) 0.4 A, 1.1 A, 0.4 A (d) –0.4 A, 0.4 A, 1.1 A

57. In the circuit shown, the potential difference between A and B is : **[11 Jan. 2019 II]**



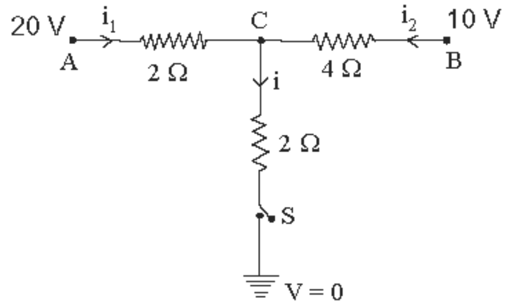
(a) 1V (b) 2V (c) 3V (d) 6V

58. In the given circuit the cells have zero internal resistance. The currents (in Amperes) passing through resistance R_1 and R_2 respectively, are: **[10 Jan. 2019 I]**



(a) 1, 2 (b) 2, 2 (c) 0.5, 0 (d) 0, 1

59. When the switch S, in the circuit shown, is closed then the valued of current *i* will be: **[9 Jan. 2019 I]**

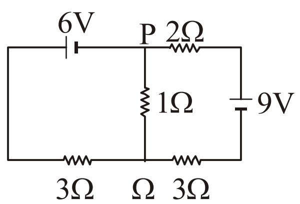


(a) 3A (b) 5A (c) 4A (d) 2A

60. Two batteries with e.m.f. 12 V and 13 V are connected in parallel across a load resistor of 10Ω. The internal resistances of the two batteries are 1Ω and 2Ω respectively. The voltage across the load lies between: **[2018]**

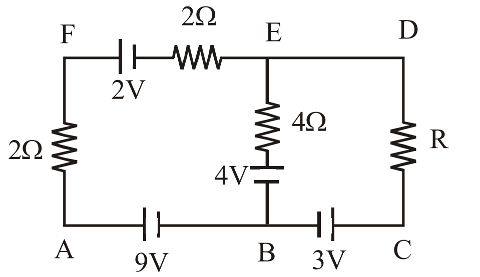
(a) 11.6 V and 11.7 V (b) 11.5 V and 11.6 V
(c) 11.4 V and 11.5 V (d) 11.7 V and 11.8 V

61. In the circuit shown, the current in the 1Ω resistor is: **[2015]**



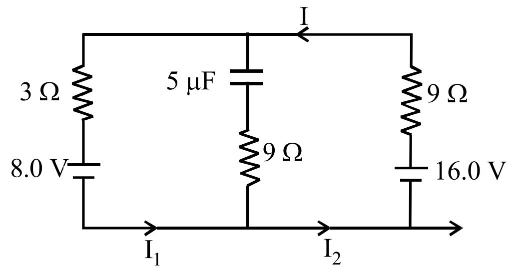
(a) 0.13 A, from Q to P (b) 0.13 A, from P to Q
(c) 1.3A from P to Q (d) 0A

62. In the electric network shown, when no current flows through the 4Ω resistor in the arm EB, the potential difference between the points A and D will be : **[Online April 11, 2015]**



(a) 6 V (b) 3 V (c) 5 V (d) 4 V

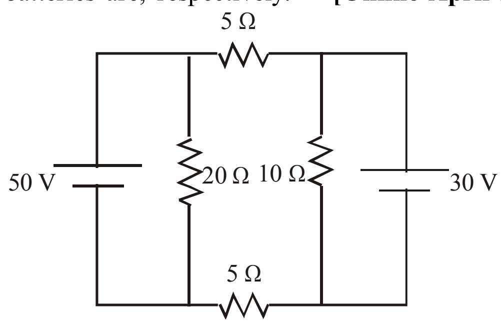
63. The circuit shown here has two batteries of 8.0 V and 16.0 V and three resistors 3 Ω, 9 Ω and 9 Ω and a capacitor of 5.0 μF. **[Online April 12, 2014]**



How much is the current I in the circuit in steady state?

(a) 1.6 A (b) 0.67 A
(c) 2.5 A (d) 0.25 A

64. In the circuit shown, current (in A) through 50 V and 30 V batteries are, respectively. **[Online April 11, 2014]**

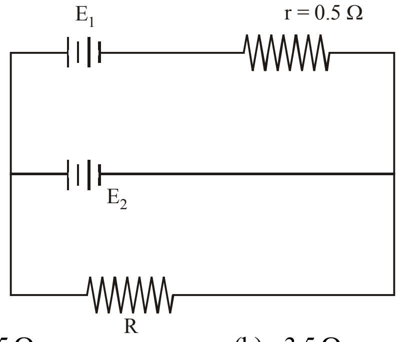


(a) 2.5 and 3 (b) 3.5 and 2
(c) 4.5 and 1 (d) 3 and 2.5

65. A d.c. main supply of e.m.f. 220 V is connected across a storage battery of e.m.f. 200 V through a resistance of 1Ω. The battery terminals are connected to an external resistance 'R'. The minimum value of 'R', so that a current passes through the battery to charge it is: **[Online April 9, 2014]**

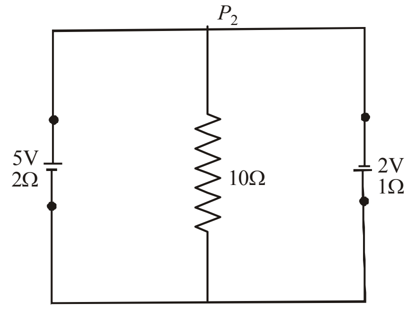
(a) 7 Ω (b) 9 Ω (c) 11 Ω (d) Zero

66. A dc source of emf E_1 = 100 V and internal resistance r = 0.5 Ω, a storage battery of emf E_2 = 90 V and an external resistance R are connected as shown in figure. For what value of R no current will pass through the battery ? **[Online April 22, 2013]**



(a) 5.5 Ω (b) 3.5 Ω
(c) 4.5 Ω (d) 2.5 Ω

67. A 5V battery with internal resistance 2Ω and a 2V battery with internal resistance 1Ω are connected to a 10Ω resistor as shown in the figure. **[2008]**



The current in the 10Ω resistor is

(a) 0.27 A P_2 to P_1 (b) 0.03 A P_1 to P_2
(c) 0.03 A P_2 to P_1 (d) 0.27 A P_1 to P_2

68. A battery is used to charge a parallel plate capacitor till the potential difference between the plates becomes equal to the electromotive force of the battery. The ratio of the energy stored in the capacitor and the work done by the battery will be **[2007]**

(a) 1/2 (b) 1 (c) 2 (d) 1/4

69. The Kirchhoff's first law ($\Sigma i = 0$) and second law ($\Sigma iR = \Sigma E$), where the symbols have their usual meanings, are respectively based on **[2006]**

(a) conservation of charge, conservation of momentum
(b) conservation of energy, conservation of charge
(c) conservation of momentum, conservation of charge
(d) conservation of charge, conservatrion of energy

70. A thermocouple is made from two metals, Antimony and Bismuth. If one junction of the couple is kept hot and the other is kept cold, then, an electric current will **[2006]**

(a) flow from Antimony to Bismuth at the hot junction
(b) flow from Bismuth to Antimony at the cold junction
(c) now flow through the thermocouple
(d) flow from Antimony to Bismuth at the cold junction

71. Two sources of equal emf are connected to an external resistance R. The internal resistance of the two sources are R_1 and R_2 ($R_1 > R_1$). If the potential difference across the source having internal resistance R_2 is zero, then **[2005]**

(a) $R = R_2 - R_1$

(b) $R = R_2 \times (R_1 + R_2)/(R_2 - R_1)$

(c) $R = R_1 R_2 /(R_2 - R_1)$

(d) $R = R_1 R_2 /(R_1 - R_2)$

72. Two voltameters, one of copper and another of silver, are joined in parallel. When a total charge q flows through the voltameters, equal amount of metals are deposited. If the electrochemical equivalents of copper and silver are Z_1 and Z_2 respectively the charge which flows through the silver voltameter is **[2005]**

(a) $\dfrac{q}{1+\dfrac{Z_2}{Z_1}}$ `(b) $\dfrac{q}{1+\dfrac{Z_1}{Z_2}}$ (c) $q\dfrac{Z_2}{Z_1}$ (d) $q\dfrac{Z_1}{Z_2}$

73. An energy source will supply a constant current into the load if its internal resistance is **[2005]**

(a) very large as compared to the load resistance
(b) equal to the resistance of the load
(c) non-zero but less than the resistance of the load
(d) zero

74. The thermo emf of a thermocouple varies with the temperature θ of the hot junction as $E = a\theta + b\theta^2$ in volts where the ratio a/b is 700°C. If the cold junction is kept at 0°C, then the neutral temperature is **[2004]**

(a) 1400°C
(b) 350°C
(c) 700°C
(d) No neutral temperature is possible for this termocouple.

75. The electrochemical equivalent of a metal is 3.35×10^{-7} kg per Coulomb. The mass of the metal liberated at the cathode when a 3A current is passed for 2 seconds will be **[2004]**

(a) 6.6×10^{57}kg (b) 9.9×10^{-7} kg
(c) 19.8×10^{-7} kg (d) 1.1×10^{-7} kg

76. The thermo e.m.f. of a thermo-couple is 25 μV/°C at room temperature. A galvanometer of 40 ohm resistance, capable of detecting current as low as 10^{-5} A, is connected with the thermo couple. The smallest temperature difference that can be detected by this system is **[2003]**

(a) 16°C (b) 12°C (c) 8°C (d) 20°C

77. The negative Zn pole of a Daniell cell, sending a constant current through a circuit, decreases in mass by 0.13g in 30 minutes. If the electeochemical equivalent of Zn and Cu are 32.5 and 31.5 respectively, the increase in the mass of the positive Cu pole in this time is **[2003]**

(a) 0.180 g (b) 0.141g (c) 0.126 g (d) 0.242 g

78. The mass of product liberated on anode in an electrochemical cell depends on **[2002]**

(a) $(It)^{1/2}$ (b) It (c) I/t (d) I^2t

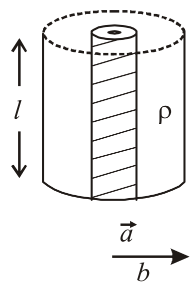
(where t is the time period for which the current is passed).

TOPIC 4 Heating Effect of Current

79. An electrical power line, having a total resistance of 2 Ω, delivers 1 kW at 220 V. The efficiency of the transmission line is approximately : **[Sep. 05, 2020 (I)]**

(a) 72% (b) 91% (c) 85% (d) 96%

80. Model a torch battery of length l to be made up of a thin cylindrical bar of radius 'a' and a concentric thin cylindrical shell of radius 'b' filled in between with an electrolyte of resistivity ρ (see figure). If the battery is connected to a resistance of value R, the maximum Joule heating in R will take place for : **[Sep. 03, 2020 (I)]**



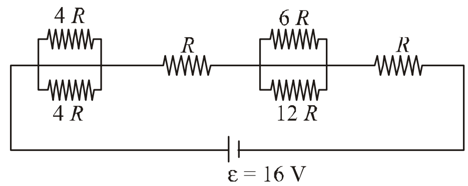
(a) $R = \dfrac{\rho}{2\pi l}\left(\dfrac{b}{a}\right)$ (b) $R = \dfrac{\rho}{2\pi l} ln\left(\dfrac{b}{a}\right)$

(c) $R = \dfrac{\rho}{\pi l} ln\left(\dfrac{b}{a}\right)$ (d) $R = \dfrac{2\rho}{\pi l} ln\left(\dfrac{b}{a}\right)$

81. In a building there are 15 bulbs of 45 W, 15 bulbs of 100 W, 15 small fans of 10 W and 2 heaters of 1 kW. The voltage of electric main is 220 V. The minimum fuse capacity (rated value) of the building will be: **[7 Jan. 2020 II]**

(a) 10 A (b) 25 A (c) 15 A (d) 20 A

82. The resistive network shown below is connected to a D.C. source of 16 V. The power consumed by the network is 4 Watt. The value of R is : **[12 Apr. 2019 I]**



(a) 6Ω (b) 8Ω (c) 1Ω (d) 16Ω

83. One kg of water, at 20°C, is heated in an electric kettle whose heating element has a mean (temperature averaged) resistance of 20 Ω. The rms voltage in the mains is 200 V. Ignoring heat loss from the kettle, time taken for water to evaporate fully, is close to :

[Specific heat of water = 4200 J/(kg°C), Latent heat of water = 2260 kJ/kg] **[12 Apr. 2019 II]**

(a) 16 minutes (b) 22 minutes
(c) 3 minutes (d) 3 minutes

84. Two electric bulbs, rated at (25 W, 220 V) and (100 W, 220 V), are connected in series across a 220 V voltage source. If the 25 W and 100 W bulbs draw powers P_1 and P_2 respectively, then: **[12 Jan. 2019 I]**

(a) P_1=16 W, P_2=4 W (b) P_1=16 W, P_2=9 W
(c) P_1=9 W, P_2=16 W (d) P_1=4 W, P_2=16 W

85. Two equal resistances when connected in series to a battery, consume electric power of 60 W. If these resistance are now connected in parallel combination to the same battery, the electric power consumed will be : **[11 Jan. 2019 I]**

(a) 60 W (b) 240 W (c) 120 W (d) 30 W

86. A 2 W carbon resistor is color coded with green, black, red and brown respectively. The maximum current which can be passed through this resistor is: **[10 Jan. 2019 I]**

(a) 20 mA (b) 100 mA (c) 0.4 mA (d) 63 mA

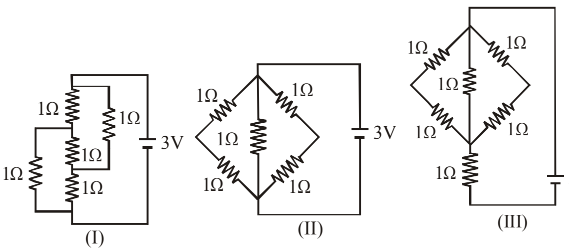
87. A current of 2 mA was passed through an unknown resistor which dissipated a power of 4.4 W. Dissipated power when an ideal power supply of 11 V is connected across it is: **[10 Jan. 2019 II]**

(a) 11×10^{-5} W (b) 11×10^{-3} W
(c) 11×10^{-4} W (d) 11×10^{5} W

88. A constant voltage is applied between two ends of a metallic wire. If the length is halved and the radius of the wire is doubled, the rate of heat developed in the wire will be: **[Online April 15, 2018]**

(a) Increased 8 times (b) Doubled
(c) Halved (d) Unchanged

89. The figure shows three circuits I, II and III which are connected to a 3V battery. If the powers dissipated by the configurations I, II and III are P_1, P_2 and P_3 respectively, then : **[Online April 9, 2017]**

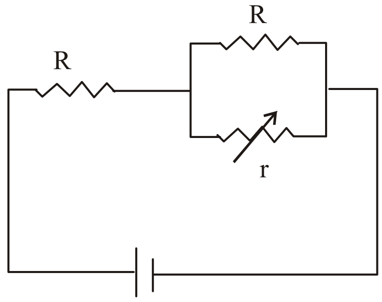


(a) $P_1 > P_2 > P_3$ (b) $P_1 > P_3 > P_2$
(c) $P_2 > P_1 > P_3$ (d) $P_3 > P_2 > P_1$

90. The resistance of an electrical toaster has a temperature dependence given by $R(T) = R_0 [1 + \alpha(T - T_0)]$ in its range of operation. At T_0 = 300K, R = 100 Ω and at T = 500 K, R = 120 Ω. The toaster is connected to a voltage source at 200 V and its temperature is raised at a constant rate from 300 to 500 K in 30 s. The total work done in raising the temperature is : **[Online April 10, 2016]**

(a) $400 \ln \frac{5}{6}$ J (b) $200 \ln \frac{2}{3}$ J
(c) 300 J (d) $400 \ln \frac{1.5}{1.3}$ J

91.



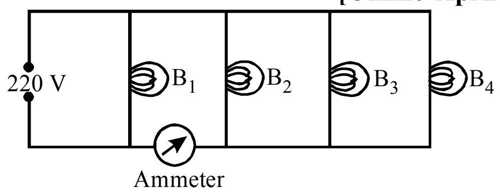
In the circuit shown, the resistance r is a variable resistance. If for r = fR, the heat generation in r is maximum then the value of f is : **[Online April 9, 2016]**

(a) $\frac{1}{2}$ (b) 1 (c) $\frac{1}{4}$ (d) $\frac{3}{4}$

92. In a large building, there are 15 bulbs of 40 W, 5 bulbs of 100 W, 5 fans of 80 W and 1 heater of 1 kW. The voltage of electric mains is 220 V. The minimum capacity of the main fuse of the building will be: **[2014]**

(a) 8 A (b) 10 A (c) 12 A (d) 14 A

93. Four bulbs B_1, B_2, B_3 and B_4 of 100 W each are connected to 220 V main as shown in the figure. **[Online April 19, 2014]**



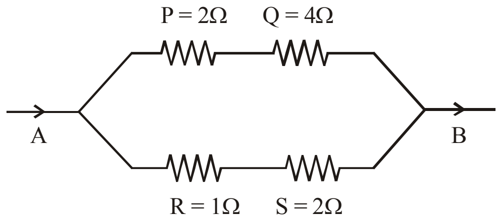
The reading in an ideal ammeter will be:

(a) 0.45 A (b) 0.90 A (c) 1.35 A (d) 1.80 A

94. The supply voltage to room is 120V. The resistance of the lead wires is 6Ω. A 60 W bulb is already switched on. What is the decrease of voltage across the bulb, when a 240 W heater is switched on in parallel to the bulb? **[2013]**

(a) zero (b) 2.9 Volt
(c) 13.3 Volt (d) 10.04 Volt

95. Which of the four resistances P, Q, R and S generate the greatest amount of heat when a current flows from A to B? **[Online April 23, 2013]**

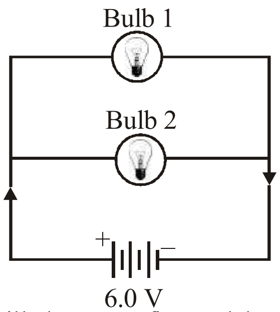


(a) Q (b) S (c) P (d) R

96. Two electric bulbs rated 25W – 220 V and 100W – 220V are connected in series to a 440 V supply. Which of the bulbs will fuse? **[2012]**

(a) Both (b) 100 W (c) 25 W (d) Neither

97. A 6.0 volt battery is connected to two light bulbs as shown in figure. Light bulb 1 has resistance 3 ohm while light bulb 2 has resistance 6 ohm. Battery has negligible internal resistance. Which bulb will glow brighter? **[Online May 19, 2012]**



(a) Bulb 1 will glow more first and then its brightness will become less than bulb 2
(b) Bulb 1
(c) Bulb 2
(d) Both glow equally

98. Three resistors of 4 Ω, 6 Ω and 12 Ω are connected in parallel and the combination is connected in series with a 1.5 V battery of 1 Ω internal resistance. The rate of Joule heating in the 4 Ω resistor is **[Online May 12, 2012]**
(a) 0.55 W (b) 0.33 W (c) 0.25 W (d) 0.86 W

99. This question has Statement 1 and Statement 2. Of the four choices given after the Statements, choose the one that best describes the two Statements.
Statement 1: The possibility of an electric bulb fusing is higher at the time of switching ON.
Statement 2: Resistance of an electric bulb when it is not lit up is much smaller than when it is lit up.
[Online May 7, 2012]
(a) Statement 1 is true, Statement 2 is false
(b) Statement 1 is false, Statement 2 is true, Statement 2 is not a correct explanation of Statement 1.
(c) Statement 1 is true, Statement 2 is true, Statement 2 is a correct explanation of Statement 1.
(d) Statement 1 is false, Statement 2 is true.

100. The resistance of a bulb filmanet is 100Ω at a temperature of 100°C. If its temperature coefficient of resistance be 0.005 per °C, its resistance will become 200 Ω at a temperature of **[2006]**
(a) 300°C (b) 400°C (c) 500°C (d) 200°C

101. An electric bulb is rated 220 volt - 100 watt. The power consumed by it when operated on 110 volt will be **[2006]**
(a) 75 watt (b) 40 watt (c) 25 watt (d) 50 watt

102. A heater coil is cut into two equal parts and only one part is now used in the heater. The heat generated will now be **[2005]**
(a) four times (b) doubled
(c) halved (d) one fourth

103. The resistance of hot tungsten filament is about 10 times the cold resistance. What will be the resistance of 100 W and 200 V lamp when not in use ? **[2005]**
(a) 20Ω (b) 40Ω (c) 200Ω (d) 400Ω

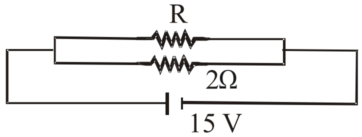
104. The thermistors are usually made of **[2004]**
(a) metal oxides with high temperature coefficient of resistivity
(b) metals with high temperature coefficient of resistivity
(c) metals with low temperature coefficient of resistivity
(d) semiconducting materials having low temperature coefficient of resistivity

105. Time taken by a 836 W heater to heat one litre of water from 10°C to 40°C is **[2004]**
(a) 150 s (b) 100 s (c) 50 s (d) 200 s

106. A 220 volt, 1000 watt bulb is connected across a 110 volt mains supply. The power consumed will be **[2003]**
(a) 750 watt (b) 500 watt
(c) 250 watt (d) 1000 watt

107. A wire when connected to 220 V mains supply has power dissipation P_1. Now the wire is cut into two equal pieces which are connected in parallel to the same supply. Power dissipation in this case is P_2. Then $P_2 : P_1$ is **[2002]**
(a) 1 (b) 4 (c) 2 (d) 3

108. If in the circuit, power dissipation is 150 W, then R is **[2002]**



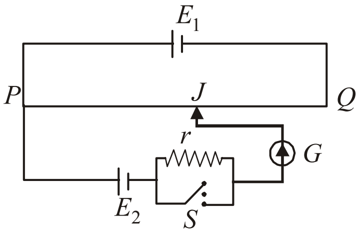
(a) 2Ω (b) 6Ω (c) 5Ω (d) 4Ω

TOPIC 5 Wheatstone Bridge and Different Measuring Instruments

109. Two resistors 400Ω and 800Ω are connected in series across a 6 V battery. The potential difference measured by a voltmeter of 10 kΩ across 400Ω resistor is close to:
[Sep. 03, 2020 (II)]
(a) 2V (b) 1.8V (c) 2.05V (d) 1.95V

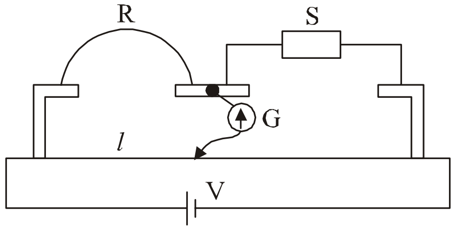
110. Which of the following will NOT be observed when a multimeter (operating in resistance measuring mode) probes connected across a component, are just reversed?
[Sep. 03, 2020 (II)]
(a) Multimeter shows an equal deflection in both cases i.e. before and after reversing the probes if the chosen component is resistor.
(b) Multimeter shows NO deflection in both cases i.e. before and after reversing the probes if the chosen component is capacitor.
(c) Multimeter shows a deflection, accompanied by a splash of light out of connected and NO deflection on reversing the probes if the chosen component is LED.
(d) Multimeter shows NO deflection in both cases i.e. before and after reversing the probes if the chosen component is metal wire.

111. A potentiometer wire PQ of 1 m length is connected to a standard cell E_1. Another cell E_2 of emf 1.02 V is connected with a resistance 'r' and switch S (as shown in figure). With switch S open, the null position is obtained at a distance of 49 cm from Q. The potential gradient in the potentiometer wire is : **[Sep. 02, 2020 (II)]**



(a) 0.02 V/cm (b) 0.01 V/cm
(c) 0.03 V/cm (d) 0.04 V/cm

112. In a meter bridge experiment S is a standard resistance. R is a resistance wire. It is found that balancing length is l = 25 cm. If R is replaced by a wire of half length and half diameter that of R of same material, then the balancing distance l' (in cm) will now be ____. **[NA. 9 Jan. 2020 II]**



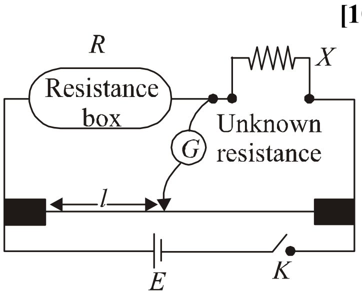
113. The length of a potentiometer wire is 1200 cm and it carries a current of 60 mA. For a cell of emf 5 V and internal resistance of 20 Ω, the null point on it is found to be at 1000 cm. The resistance of whole wire is: **[8 Jan. 2020 I]**

(a) 80 Ω (b) 120 Ω (c) 60 Ω (d) 100 Ω

114. Four resistances of 15 Ω, 12 Ω, 4 Ω and 10 Ω respectively in cyclic order to form Wheatstone's network. The resistance that is to be connected in parallel with the resistance of 10 Ω to balance the network is _____ Ω. **[NA. 8 Jan. 2020 I]**

115. The balancing length for a cell is 560 cm in a potentiometer experiment. When an external resistance of 10 Ω is connected in parallel to the cell, the balancing length changes by 60 cm. If the internal resistance of the cell is $\frac{N}{10}$ Ω, where N is an integer then value of N is ________. **[NA. 7 Jan. 2020 II]**

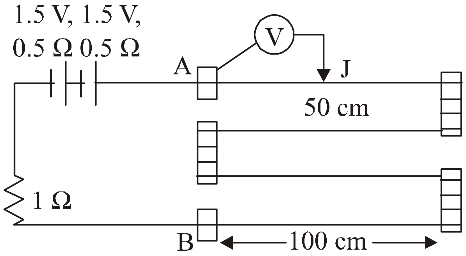
116. In a meter bridge experiment, the circuit diagram and the corresponding observation table are shown in figure. **[10 Apr. 2019 I]**



Sl.No.	RΩ	l (cm)
1.	1000	60
2.	100	13
3.	10	1.5
4.	1	1.0

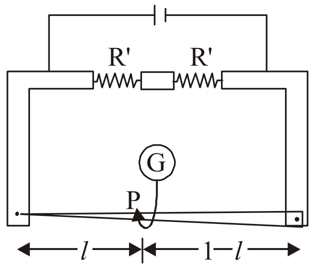
Which of the reading is consistent ?
(a) 3 (b) 2 (c) 4 (d) 1

117. In the circuit shown, a four-wire potentiometer is made of a 400 cm long wire, which extends between A and B. The resistance per unit length of the potentiometer wire is r = 0.01 Ω/cm. If an ideal voltmeter is connected as shown with jockey J at 50 cm from end A, the expected reading of the voltmeter will be : **[8 Apr. 2019 II]**



(a) 0.50 V (b) 0.75 V (c) 0.25 V (d) 0.20 V

118. In a meter bridge, the wire of length 1 m has a non-uniform cross-section such that, the variation $\frac{dR}{dl}$ of its resistance R with length l is $\frac{dR}{dl} \propto \frac{1}{\sqrt{l}}$. Two equal resistances are connected as shown in the figure. The galvanometer has zero deflection when the jockey is at point P. What is the length AP? **[12 Jan. 2019 I]**

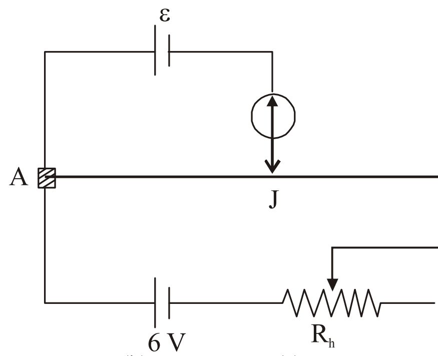


(a) 0.2 m (b) 0.3 m (c) 0.25 m (d) 0.35 m

119. An ideal battery of 4 V and resistance R are connected in series in the primary circuit of a potentionmeter of length 1 m and resistance 5Ω. The value of R, to give a potential difference of 5 mV across 10 cm of potentiometer wire is: **[12 Jan. 2019 I]**

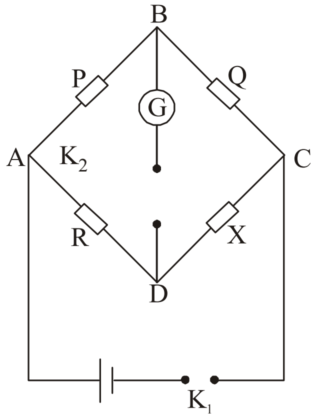
(a) 490Ω (b) 480Ω (c) 395Ω (d) 495Ω

120. The resistance of the meter bridge AB in given figure is 4Ω. With a cell of emf ε = 0.5 V and rheostat resistance R_h = 2Ω the null point is obtained at some point J. When the cell is replaced by another one of emf ε = ε_2 the same null point J is found for R_h = 6Ω. The emf ε_2 is: **[11 Jan. 2019 I]**



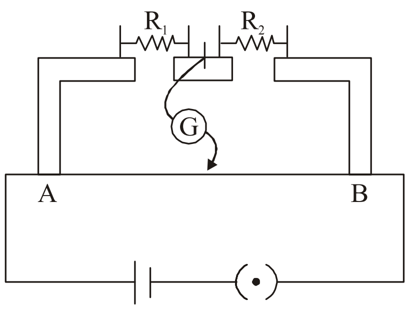
(a) 0.4 V (b) 0.3 V (c) 0.6 V (d) 0.5 V

121. In a Wheatstone bridge (see fig.), Resistances P and Q are approximately equal. When R = 400 Ω, the bridge is balanced. On interchanging P and Q, the value of R, for balance, is 405Ω. The value of X is close to : **[11 Jan. 2019 I]**



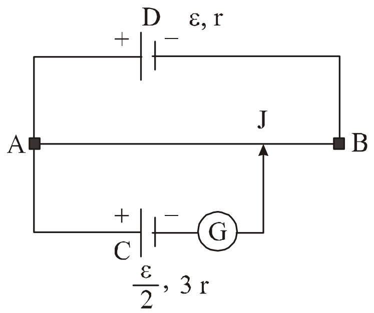
(a) 401.5 ohm (b) 404.5 ohm
(c) 403.5 ohm (d) 402.5 ohm

122. In the experimental set up of metre bridge shown in the figure, the null point is obtaine data distance of 40 cm from A. If a 10 Ω resistor is connected in series with R_1, the null point shifts by 10 cm. The resistance that should be connected in parallel with $(R_1 + 10)$ Ω such that the null point shifts back to its initial position is :
[11 Jan. 2019 II]



(a) 20 Ω (b) 40 Ω (c) 60 Ω (d) 30 Ω

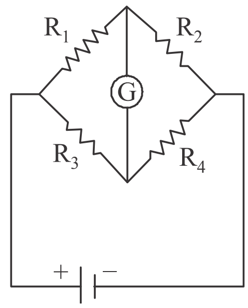
123. A potentiometer wire AB having length L and resistance 12 r is joined to a cell D of emf ε and internal resistance r. A cell C having emf ε/2 and internal resistance 3r is connected. The length AJ at which the galvanometer as shown in fig. shows no deflection is: **[10 Jan. 2019 I]**



(a) $\frac{11}{12}L$ (b) $\frac{11}{24}L$ (c) $\frac{13}{24}L$ (d) $\frac{5}{12}L$

124. The Wheatstone bridge shown in Fig. here, gets balanced when the carbon resistor used as R_1 has the colour code (Orange, Red, Brown). The resistors R_2 and R_4 are 80 Ω and 40 Ω, respectively.

Assuming that the colour code for the carbon resistors gives their accurate values, the colour code for the carbon resistor, used as R_3, would be: **[10 Jan. 2019 II]**



(a) Brown, Blue, Brown (b) Brown, Blue, Black
(c) Red, Green, Brown (d) Grey, Black, Brown

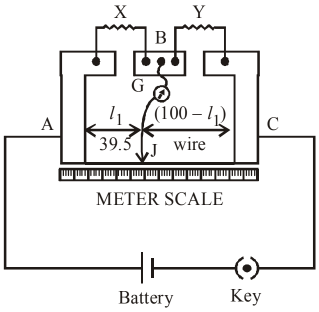
125. In a potentiometer experiment, it is found that no current passes through the galvanometer when the terminals of the cell are connected across 52 cm of the potentiometer wire. If the cell is shunted by a resistance of 5 Ω, a balance is found when the cell is connected across 40 cm of the wire. Find the internal resistance of the cell. **[2018]**

(a) 1 Ω (b) 1.5 Ω (c) 2 Ω (d) 2.5 Ω

126. On interchanging the resistances, the balance point of a meter bridge shifts to the left by 10 cm. The resistance of their series combination is 1kΩ. How much was the resistance on the left slot before interchanging the resistances?
[2018]

(a) 990 Ω (b) 505 Ω (c) 550 Ω (d) 910 Ω

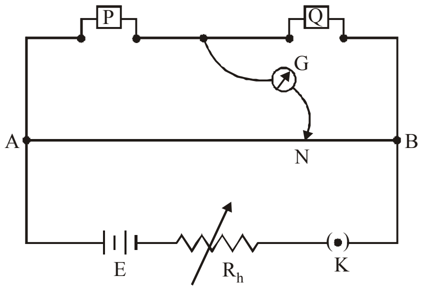
127. In a meter bridge, as shown in the figure, it is given that resistance Y=12.5 Ω and that the balance is obtained at a distance 39.5 cm from end *A* (by jockey J). After interchanging the resistances *X* and *Y*, a new balance point is found at a distance l_2 from end *A*. What are the values of *X* and l_2 ? **[Online April 15, 2018]**



(a) 19.15 Ω and 39.5 cm (b) 8.16 Ω and 60.5 cm
(c) 19.15 Ω and 60.5 cm (d) 8.16 Ω and 39.5 cm

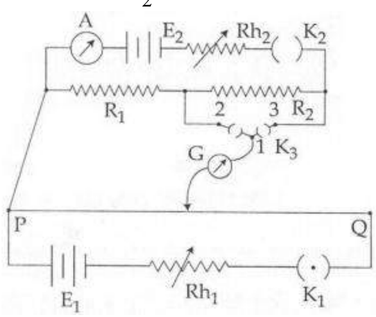
128. Which of the following statements is false ? **[2017]**
(a) A rheostat can be used as a potential divider
(b) Kirchhoff's second law represents energy conservation
(c) Wheatstone bridge is the most sensitive when all the four resistances are of the same order of magnitude
(d) In a balanced wheatstone bridge if the cell and the galvanometer are exchanged, the null point is disturbed.

129. In a meter bridge experiment resistances are connected as shown in the figure. Initially resistance P = 4 Ω and the neutral point N is at 60 cm from A. Now an unknown resistance R is connected in series to P and the new position of the neutral point is at 80 cm from A. The value of unknown resistance R is : **[Online April 9, 2017]**



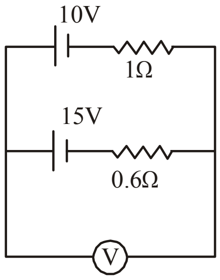
(a) $\frac{33}{5}$ Ω (b) 6 Ω (c) 7 Ω (d) $\frac{20}{3}$ Ω

130. A potentiometer PQ is set up to compare two resistances as shown in the figure. The ammeter A in the circuit reads 1.0 A when two way key K_3 is open. The balance point is at a length l_1 cm from P when two way key K_3 is plugged in between 2 and 1, while the balance point is at a length l_2 cm from P when key K_3 is plugged in between 3 and 1. The ratio of two resistances $\frac{R_1}{R_2}$, is found to be : **[Online April 8, 2017]**



(a) $\frac{l_1}{l_1 + l_2}$ (b) $\frac{l_2}{l_2 - l_1}$ (c) $\frac{l_1}{l_1 - l_2}$ (d) $\frac{l_1}{l_2 - l_1}$

131. A 10V battery with internal resistance 1Ω and a 15V battery with internal resistance 0.6 Ω are connected in parallel to a voltmeter (see figure). The reading in the voltmeter will be close to : **[Online April 10, 2015]**



(a) 12.5 V (b) 24.5 V (c) 13.1 V (d) 11.9 V

132. In an experiment of potentiometer for measuring the internal resistance of primary cell a balancing length ℓ is obtained on the potentiometer wire when the cell is open circuit. Now the cell is short circuited by a resistance R. If R is to be equal to the internal resistance of the cell the balancing length on the potentiometer wire will be **[Online May 26, 2012]**
(a) ℓ (b) 2ℓ (c) $\ell/2$ (d) $\ell/4$

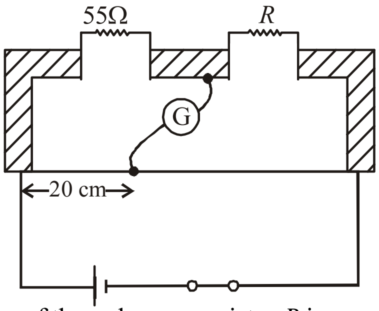
133. It is preferable to measure the e.m.f. of a cell by potentiometer than by a voltmeter because of the following possible reasons. **[Online May 12, 2012]**
(i) In case of potentiometer, no current flows through the cell.
(ii) The length of the potentiometer allows greater precision.
(iii) Measurement by the potentiometer is quicker.
(iv) The sensitivity of the galvanometer, when using a potentiometer is not relevant.
Which of these reasons are correct?
(a) (i), (iii), (iv) (b) (i), (iii), (iv)
(c) (i), (ii) (d) (i), (ii), (iii), (iv)

134. In a sensitive meter bridge apparatus the bridge wire should possess **[Online May 12, 2012]**
(a) high resistivity and low temperature coefficient.
(b) low resistivity and high temperature coefficient.
(c) low resistivity and low temperature coefficient.
(d) high resistivity and high temperature coefficient.

135. In a metre bridge experiment null point is obtained at 40 cm from one end of the wire when resistance X is balanced against another resistance Y. If X < Y, then the new position of the null point from the same end, if one decides to balance a resistance of 3X against Y, will be close to : **[Online April 9, 2013]**
(a) 80 cm (b) 75 cm (c) 67 cm (d) 50 cm

136. The current in the primary circuit of a potentiometer is 0.2 A. The specific resistance and cross-section of the potentiometer wire are 4×10^{-7} ohm metre and 8×10^{-7} m^2, respectively. The potential gradient will be equal to **[2011 RS]**
(a) 1 V/m (b) 0.5 V/m (c) 0.1 V/m (d) 0.2 V/m

137. Shown in the figure below is a meter-bridge set up with null deflection in the galvanometer.



The value of the unknown resistor R is **[2008]**

(a) 13.75 Ω (b) 220 Ω (c) 110 Ω (d) 55 Ω

138. In a Wheatstone's bridge, three resistances P, Q and R connected in the three arms and the fourth arm is formed by two resistances S_1 and S_2 connected in parallel. The condition for the bridge to be balanced will be **[2006]**

(a) $\frac{P}{Q} = \frac{2R}{S_1 + S_2}$ (b) $\frac{P}{Q} = \frac{R(S_1 + S_2)}{S_1 S_2}$

(c) $\frac{P}{Q} = \frac{R(S_1 + S_2)}{2S_1 S_2}$ (d) $\frac{P}{Q} = \frac{R}{S_1 + S_2}$

139. In a potentiometer experiment the balancing with a cell is at length 240 cm. On shunting the cell with a resistance of 2Ω, the balancing length becomes 120 cm. The internal resistance of the cell is **[2005]**

(a) 0.5Ω (b) 1Ω (c) 2Ω (d) 4Ω

140. In a meter bridge experiment null point is obtained at 20 cm. from one end of the wire when resistance X is balanced against another resistance Y. If $X < Y$, then where will be the new position of the null point from the same end, if one decides to balance a resistance of 4 X against Y **[2004]**

(a) 40 cm (b) 80 cm (c) 50 cm (d) 70 cm

141. The length of a wire of a potentiometer is 100 cm, and the e. m.f. of its standard cell is E volt. It is employed to measure the e.m.f. of a battery whose internal resistance is 0.5Ω. If the balance point is obtained at $\ell = 30$ cm from the positive end, the e.m.f. of the battery is **[2003]**

(a) $\frac{30E}{100.5}$ (b) $\frac{30E}{(100-0.5)}$

(c) $\frac{30(E-0.5i)}{100}$ (d) $\frac{30E}{100}$

where i is the current in the potentiometer wire.

142. An ammeter reads upto 1 ampere. Its internal resistance is 0.81ohm. To increase the range to 10 A the value of the required shunt is **[2003]**

(a) 0.03 Ω (b) 0.3 Ω (c) 0.9 Ω (d) 0.09 Ω

143. If an ammeter is to be used in place of a voltmeter, then we must connect with the ammeter a **[2002]**

(a) low resistance in parallel
(b) high resistance in parallel
(c) high resistance in series
(d) low resistance in series.

Hints & Solutions

1. **(c)** **Ammeter :** In series connection, the same current flows through all the components. It aims at measuring the current flowing through the circuit and hence, it is connected in series.

   Voltmeter : A voltmeter measures voltage change between two points in a circuit. So we have to place the voltmeter in parallel with the cicuit component.

2. **(b)** $\rho_M = 98 \times 10^{-8}$

   $\rho_A = 2.65 \times 10^{-8}$

   $\rho_C = 1.724 \times 10^{-8}$

   $\rho_T = 5.65 \times 10^{-8}$

   $\therefore \rho_M > \rho_T > \rho_A > \rho_C$

3. **(a)** When $i = 0$, $V = \varepsilon = 1.5$ volt

4. **(d)** Charge mobility

   $(\mu) = \frac{V_d}{E}$ [Where V_d = drift velocity]

   and resistivity $(\rho) = \frac{E}{j} = \frac{EA}{I} \Rightarrow E = \frac{I(\rho)}{A}$

   $\Rightarrow \mu = \frac{V_d}{E} = \frac{V_d A}{I_\rho}$

   $= \frac{1.1 \times 10^{-3} \times \pi \times \left(5 \times 10^{-3}\right)^2}{5 \times 1.7 \times 10^{-8}}$

   $\mu = 1.0 \frac{m^2}{V_s}$

5. **(b)** Equation of straight line from graph
   $y = -mx + c$

   $\Rightarrow l\text{n}R = -m\left(\frac{1}{T^2}\right) + c$

   here, m & c are constants

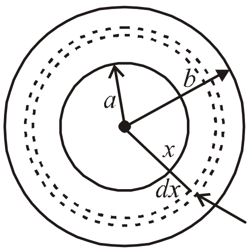
   $R = e^{\left[-m\left(\frac{1}{T^2}\right)+c\right]} = e^{-m\left(\frac{1}{T^2}\right)} \times e^c$

   $R(T) = R_0 e^{\frac{-T_0^2}{T^2}}$

6. **(a)** $dR = \frac{(\rho)(dx)}{4\pi x^2}$

   $R = \int dR$

   $\int dR = \rho \int_a^b \frac{dx}{4\pi x^2}$



   $\Rightarrow R = \frac{\rho}{4\pi}\left[\frac{-1}{x}\right]_a^b$

   $R = \left(\frac{\rho}{4\pi}\right) \cdot \left(\frac{1}{a} - \frac{1}{b}\right)$

7. **(c)** $\rho = \frac{m}{ne^2\tau}$

   $= \frac{9.1 \times 10^{-31}}{8.5 \times 10^{28} \times (1.6 \times 10^{-19})^2 \times 25 \times 10^{-15}}$

   $= 10^{-8}\,\Omega$-m

8. **(d)** Number 2 is associated with the red colour. This colour is replaced by green.

   $\because$ Colour code figure for green is 5

   $\therefore$ New resistance = 500 Ω

9. **(a)** Clearly, from graph

   Current, $I = \frac{dq}{dt} = 0$ at $t = 4s$ [Since q is constant]

10. **(b)** Color code : Bl, Br, R, O, Y, G, B, V, Gr, W
    0, 1, 2, 3, 4, 5, 6, 7, 8 9

    R = AB × C ± D% where D = tolerance

    $D_{gold} = \pm 5\%$, $D_{silver} = \pm 10\%$; $D_{no\ colour} = \pm 20\%$

    Red voilet orange silver

    R = 27 × 10^3 Ω ± 10% = 27 kΩ ± 10%

11. **(a)** Using, $I = neAv_d$

    $\therefore$ Drift speed $v_d = \frac{1}{neA}$

    $\frac{1.5}{9 \times 10^{28} \times 1.6 \times 10^{-19} \times 5 \times 10^{-6}} = 0.02\ \text{mms}^{-1}$

12. **(c)** Resistance, $R = \frac{\rho \ell}{A}$

    $R = \rho \frac{\ell}{A} \times \frac{\ell}{\ell} = \frac{\rho \ell^2}{V}$ [≫Volume (V) = A≫.]

    Since resistivity and volume remains constant therefore % change in resistance

    $\frac{\Delta R}{R} = \frac{2\Delta \ell}{\ell} = 2 \times (0.5) = 1\%$

13. **(a)** Colour code for carbon resistor

    Bl, Br, R, O, Y, G, Blue, V, Gr, W

    0 1 2 3 4 5 6 7 8 9

    Resistance, R = AB × C ± D

    Bands A and B are the first two significant figures of resistance

    B and C indicates the decimal multiplier or the number of zeros that follow A and B

    B and D is tolerance: Gold = ± 5%,

    Silver = ± 10 % No colour = ± 20%

    $R = 53 \times 10^4 \pm 5\% = 530\,\text{k}\Omega \pm 5\%$

14. **(c)** Resistance after temperature increases by 500°C i.e.,

$$R_t = \frac{V}{I} = \frac{220}{2} = 110\Omega$$

$R_0 = 100$ (given) temperature coefficient of resistance, $\alpha = ?$
using $R_t = R_0(1+\alpha t)$
$110 = 100(1+\alpha 500)$

$$\alpha = \frac{10}{100 \times 500}$$

or, $\alpha = 2 \times 10^{-4} °C^{-1}$

15. **(c)** Charge density $\rho = \frac{\text{charge}}{\text{volume}} = \frac{q}{Ad} \Rightarrow q = \rho Ad$

Also, $q = IT \Rightarrow T = \frac{q}{I} = \frac{\rho Ad}{I}$

16. **(a)** Given, $R_1 = 100\,\Omega$, $r' = r/2$, $R_2 = ?$

Resistivity of wire, $R = \frac{\rho l}{A}$ $\because$ Area × length = volume

Hence, $R = \frac{\rho V}{A^2}$

Since, $\rho \to$ constant, $V \to$ constant

$$R \propto \frac{1}{A^2}$$

or $R \propto \frac{1}{r^4}$ $\because A = \pi r^2$

$\frac{R_2}{R_1} = 16 \Rightarrow R_2 = 16 \times 100 = 1600\,\Omega$, Resistance of new wire.

17. **(b)** $V = IR = (neAv_d)\rho\frac{\ell}{A}$

$\therefore \rho = \frac{V}{V_d lne}$

Here V = potential difference
l = length of wire
n = no. of electrons per unit volume of conductor.
e = no. of electrons
Placing the value of above parameters we get resistivity

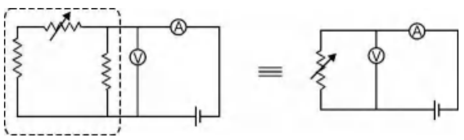
$$\rho = \frac{5}{8 \times 10^{28} \times 1.6 \times 10^{-19} \times 2.5 \times 10^{-4} \times 0.1}$$

$= 1.6 \times 10^{-5}\Omega$m

18. **(c)** $i = neAV_d$ and $V_d \propto \sqrt{E}$ (Given)

or, $i \propto \sqrt{E}$
$i^2 \propto E$
$i^2 \propto V$
Hence graph (c) correctly dipicts the *V-I* graph for a wire made of such type of material.

19. **(a)** In ohm's law, we check V = IR where I is the corrent flowing through a resistor and V is the potential difference across that resistor. Only option (a) fits the above criteria. Remember that ammeter is connected in series with resistance and voltmeter parallel with the resistance.



20. **(c)** Resistance of wire $(R) = \rho\frac{l}{A}$

If wire is bent in the middle then

$l' = \frac{l}{2}, A' = 2A$

$\therefore$ New resistance, $R' = \rho\frac{l'}{A'}$

$$= \frac{\rho\frac{l}{2}}{2A} = \frac{\rho l}{4A} = \frac{R}{4}.$$

21. **(a)** Resistance of wire

$$R = \frac{\rho l}{A} = \frac{\rho l^2}{V} \quad (\because V = A\ell)$$

Hence, $R = \rho\frac{\ell^2}{V}$ = constant × ℓ^2

$\therefore$ Fractional change in resistance

$$\frac{\Delta R}{R} = 2\frac{\Delta l}{l}$$

$$100 \times \frac{\Delta R}{R} = 200 \times \left(\frac{d\ell}{\ell}\right)$$

$\because d\ell/\ell = 0.1\%$

$\therefore$ % change in $R = \left[200 \times \left\{\frac{0.1}{100}\right\}\right] = 0.2\%$

$\therefore$ Resistance will increase by 0.2%.

22. **(a)** Let j be the current density.

Then $j \times 2\pi r^2 = I \Rightarrow j = \frac{I}{2\pi r^2}$

$\therefore E = \rho j = \frac{\rho I}{2\pi r^2}$

Now, $V_B - V_C$

$$= -\int_{a+b}^{a} \vec{E} \cdot \vec{dr} = -\int_{a+b}^{a} \frac{\rho I}{2\pi r^2} dr$$

$$= -\frac{\rho I}{2\pi}\left[-\frac{1}{r}\right]_{a+b}^{a} = \frac{\rho I}{2\pi a} - \frac{\rho I}{2\pi(a+b)}$$

On applying superposition as mentioned we get

$$\Delta V_{BC} = 2 \times \Delta V'_{BC} = \frac{\rho I}{\pi a} - \frac{\rho I}{\pi(a+b)}$$

23. **(c)** As shown in Answer (a) $E = \frac{\rho I}{2\pi r^2}$

24. **(d)** Resistance of a metal conductor at temperature t°C is given by

$R_t = R_0(1+\alpha t)$,

R_0 is the resistance of the wire at 0ºC

and α is the temperature coefficient of resistance.

Resistance at 50°C, $R_{50} = R_0(1+50\alpha)$ .. (i)

Resistance at 100°C, $R_{100} = R_0(1+100\alpha)$ ... (ii)

From (i), $R_{50} - R_0 = 50\alpha R_0$ ... (iii)

From (ii), $R_{100} - R_0 = 100\alpha R_0$ ... (iv)

Dividing (iii) by (iv), we get

$$\frac{R_{50}-R_0}{R_{100}-R_0}=\frac{1}{2}$$

Here, $R_{50}=5\Omega$ and $R_{100}=6\Omega$

$$\therefore\ \frac{5-R_0}{6-R_0}=\frac{1}{2}$$

or, $6-R_0=10-2R_0$ or, $R_0=4\Omega$.

25. **(d)** Let d_A and d_B are the diameter of wire A and B respectively. Let ρ_B and ρ_A be the resistivity of wire A and B. We have given

$\rho_B=2\rho_A$

$d_B=2d_A$

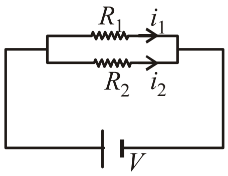
If both resistances are equal

$R_B=R_A$

$$\Rightarrow \frac{\rho_B \ell_B}{A_B}=\frac{\rho_A \ell_A}{A_A}$$

$$\therefore \frac{\ell_B}{\ell_A}=\frac{\rho_A}{\rho_B}\times\frac{d_B^2}{d_A^2}=\frac{\rho_A}{2\rho_A}\times\frac{4d_A^2}{d_A^2}=2$$

26. **(b)**



Given,

$$\frac{\ell_1}{\ell_2}=\frac{4}{3} \text{ and } \frac{r_1}{r_2}=\frac{2}{3}$$

$$R_1=\frac{\rho\ell_1}{\pi r_1^2};\ R_2=\frac{\rho\ell_2}{\pi r_2^2}$$

When wires are in parallel to the circuit potential difference across each wire is same

$i_1R_1=i_2R_2$

$$\therefore\ \frac{i_1}{i_2}=\frac{R_2}{R_1}=\frac{\rho\ell_2}{\pi r_2^2}\times\frac{\pi r_1^2}{\rho r_1}=\frac{\ell_2}{\ell_1}\times\frac{r_1^2}{r_2^2}$$

$$=\frac{3}{4}\times\frac{4}{9}=\frac{1}{3}$$

27. **(d)** Since volume of wire remains unchanged on increasing length, hence

$A\times\ell==A'\times\ell'$

$\Rightarrow \ell'=2\ell$

$$\therefore\ A'=\frac{A\times\ell}{\ell'}=\frac{A\times\ell}{2\ell}=\frac{A}{2}$$

Percentage change in resistance

$$=\frac{R_f-R_i}{R_i}\times 100=\frac{\rho\frac{\ell'}{A'}-\beta\frac{\ell}{A}}{\rho\frac{\ell}{A}}\times 100$$

$$=\left[\left(\frac{\ell'}{A'}\times\frac{A}{\ell}\right)-1\right]\times 100$$

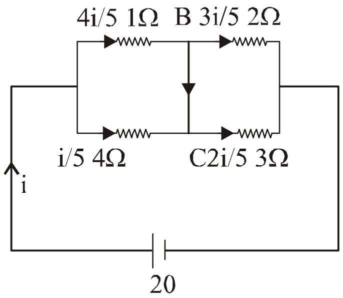
$$=\left[\left(\frac{2\ell}{A/2}\times\frac{A}{\ell}\right)-1\right]\times 100=(4-1)\times 100$$

$=300\%$

28. **(b)** From circuit diagram,

$$\frac{1}{R_1}=\frac{1}{1}+\frac{1}{4}\Rightarrow R_1=\frac{4}{5}$$

$$\frac{1}{R_2}=\frac{1}{2}+\frac{1}{3}\Rightarrow R_2=\frac{6}{5}$$

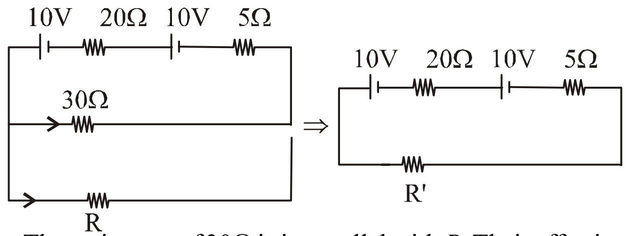


$$R_{\text{eff}}=R_1+R_2=\frac{4}{5}+\frac{6}{5}=2\Omega$$

$$i=\frac{v}{R_{\text{eff}}}=\frac{20}{2}=10A$$

$$\therefore\ I_{BC}=\frac{4i}{5}-\frac{3i}{5}=\frac{i}{5}=2A$$

29. **(30.00)**



The resistance of 30Ω is in parallel with R. Their effective resistance

$$\frac{1}{R'}=\frac{1}{30}+\frac{1}{R}$$

$$R'=\frac{30R}{30+R} \qquad \text{...(i)}$$

Also, V = IR $\Rightarrow 10=\dfrac{20\times 20}{R'+25}$

$\Rightarrow R'+25=40\Rightarrow R'=15$

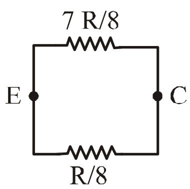
$$R'=15=\frac{30R}{30+R} \qquad \text{Using (i)}$$

$\Rightarrow 30+R=2R$

$\Rightarrow R=30\ \Omega$

30. **(c)**

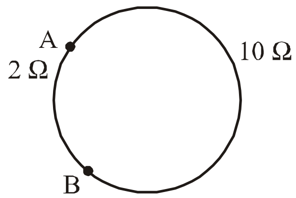
31. **(b)** $R_{eq}=\dfrac{\left(\frac{7R}{8}\right)\left(\frac{R}{8}\right)}{R}=\dfrac{7R}{64}$



32. **(c)** When length becomes double its resistance becomes $(R \propto l^2)$

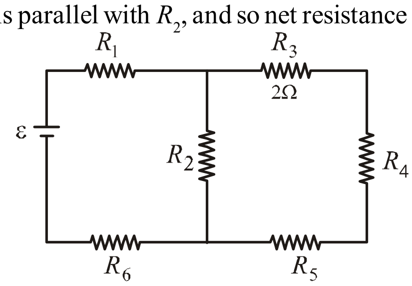
$R = 4 \times 3 = 12\,\Omega$

$R_{eq} = \dfrac{2 \times 10}{12} = \dfrac{5}{3}\Omega$



33. **(c)** R_3, R_4 and R_5 are in series so their equivalent $R = 20 + 5 + 25 = 50\,\Omega$

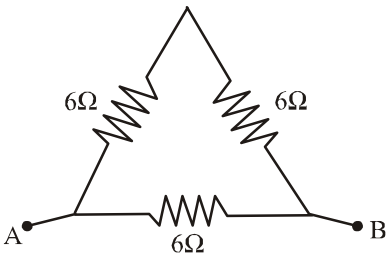
This is parallel with R_2, and so net resistance of the circuit



$$R_{eq} = \left(\frac{10 \times 50}{10 + 50}\right) + 15 + 30 = \frac{160}{3}\Omega$$

So, $i = \dfrac{\varepsilon}{R_{eq}} = \dfrac{15}{(100/3)} = \dfrac{9}{32}A$

34. **(a)**



Resistance, $R \propto l$ so resistance of each side of the equilateral triangle $= 6\,\Omega$

Resistance R_{eq} between any two vertices

$$\frac{1}{R_{eq}} = \frac{1}{12} + \frac{1}{6} \Rightarrow R_{eq.} = 4\Omega$$

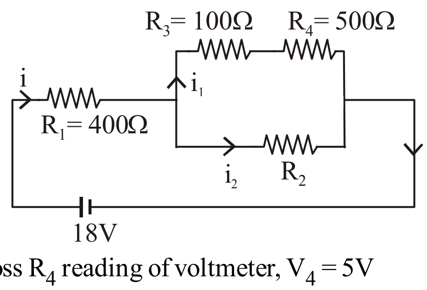
35. **(b)** Using, $\dfrac{1}{R_{eq}} = \dfrac{1}{R_1} + \dfrac{1}{R_2}$

$0.95\,R = \dfrac{RR\upsilon}{R + R\upsilon}$ (measured value 5% less then internal resistance of voltmeter)

or, $0.95 \times 30 = 0.05\,R\upsilon$

$\therefore\ R\upsilon = 19 \times 30 = 570\,\Omega$

36. **(a)**



Across R_4 reading of voltmeter, $V_4 = 5V$

Current, $i_4 = \dfrac{V_4}{R_4} = 0.01A$

$V_3 = i_1 R_3 = 1V$

$V_3 + V_4 = 6V = V_2$

$V_1 + V_3 + V_4 = 18V$

$\Rightarrow V_1 = 12\,V$

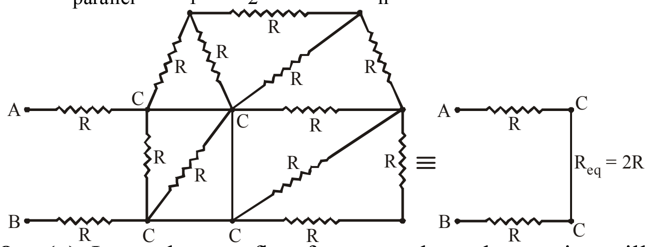
$i = \dfrac{V_1}{R_1} = 0.03A$

$i = i_1 + i_2 \Rightarrow i_2 = i - i_1 = 0.03 - 0.01A = 0.02\,A$

$\therefore R_2 = \dfrac{V_2}{i_2} = \dfrac{6}{0.02} = 300\Omega$

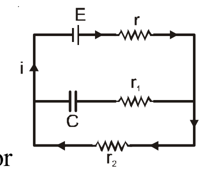
37. **(a)** $R_{series} = R_1 + R_2 + ... + R_n$

$$\frac{1}{R_{parallel}} = \frac{1}{R_1} + \frac{1}{R_2} + ... + \frac{1}{R_n}$$



38. **(a)** In steady state, flow fo current through capacitor will be zero.

Current through the circuit,



$$i = \frac{E}{r + r_2}$$

Potential difference through capacitor

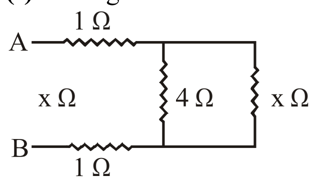
$$V_c = \frac{Q}{C} = E - ir = E - \left(\frac{E}{r + r_2}\right)r$$

$$\therefore \quad Q = CE\frac{r_2}{r + r_2}$$

39. **(b)** The potential difference in each loop is zero.

$\therefore$ No current will flow or current in each resistance is Zero.

40. **(a)** The given circuit can be redrawn as,



as $4\,\Omega$ and $x\,\Omega$ are parallel $x' = \dfrac{1}{4} + \dfrac{1}{x} = \dfrac{(4 + x)}{4x}$

$$x' = \frac{4x}{4 + x}$$

& $1\,\Omega$ and $1\,\Omega$ are also parallel $x'' = 2\,\Omega$

Now equivalent resistance of circuit

$$x = \frac{4x}{4 + x} + 2 = \frac{8 + 6x}{4 + x}$$

$4x + x^2 = 8 + 6x$

$x^2 - 2x - 8 = 0$

$$x = \frac{2 \pm \sqrt{4-4(1)(-8)}}{2} = \frac{2 \pm \sqrt{36}}{2} = \frac{2 \pm 6}{2} = 4\Omega$$

Reading of Ammeter $A_1 = \frac{V}{(R+r)}$

$$A_1 = \frac{9}{4+0.5} = 2 \text{ Ampere}$$

41. **(b)** Resistance between P and Q

$$r_{PQ} = r \,||\left(\frac{r}{3}+\frac{r}{2}\right) = \frac{r \times \frac{5}{6}r}{r+\frac{5}{6}r} = \frac{5}{11}r$$

Resistance between Q and R

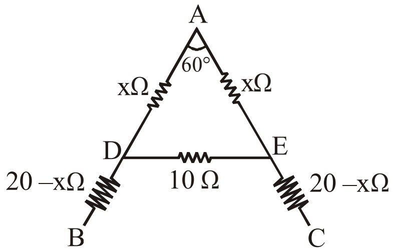
$$r_{QR} = \frac{r}{2} \,||\, (r+\frac{r}{3}) = \frac{\frac{r}{2} \times \frac{4}{3}r}{\frac{r}{2}+\frac{4}{3}r} = \frac{4}{11}r$$

Resistance between P and R

$$r_{PR} = \frac{r}{3} \,||\left(\frac{r}{2}+r\right) = \frac{\frac{r}{3} \times \frac{3}{2}r}{\frac{r}{3}+\frac{3}{2}r} = \frac{3}{11}r$$

Hence, it is clear that r_{PQ} is maximum

42. **(d)**



For ADE $\frac{1}{R'} = \frac{1}{2x} + \frac{1}{10}$

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

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

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

Solving we get

$x = 10\,\Omega$

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

We get

$$R_{BC} = \frac{20 \times 10}{10 + 2 \times 10} + 20 - 10 + 20 - 10$$

$$= \frac{80}{3} = 26.7\,\Omega$$

43. **(d)** Let R_1 and R_2 be the resistances of two conductors, then

$R_1 = R_0[1+\alpha_1 \Delta t]$

$R_2 = R_0[1+\alpha_2 \Delta t]$

Here, R_0 is the resistance of conductor at 0°C

In Series, $R = R_1 + R_2$

$= R_0[2+(\alpha_1+\alpha_2)\Delta t]$

$= 2R_0\left[1+\left(\frac{\alpha_1+\alpha_2}{2}\right)\Delta t\right]$

$\therefore \alpha_{eq} = \frac{\alpha_1+\alpha_2}{2}$

In Parallel, $\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2}$

$= \frac{1}{R_0[1+\alpha_1 \Delta t]} + \frac{1}{R_0[1+\alpha_2 \Delta t]}$

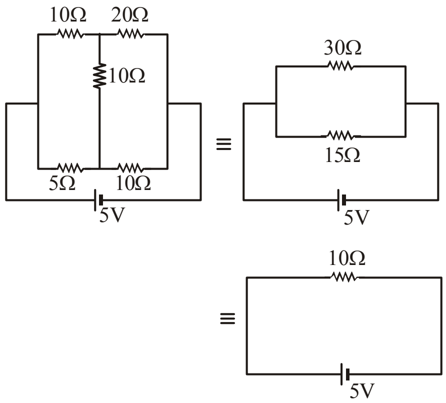
$\Rightarrow \frac{1}{\frac{R_0}{2}(1+\alpha_{eq}\Delta t)}$

$= \frac{1}{R_0(1+\alpha_1 \Delta t)} + \frac{1}{R_0(1+\alpha_2 \Delta t)}$

$2(1-\alpha_{eq}\Delta t) = (1-\alpha_1 \Delta t)(1-\alpha_2 \Delta t)$

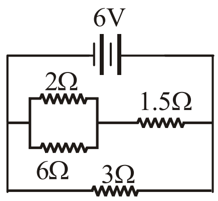
$\therefore \alpha_{eq} = \frac{\alpha_1+\alpha_2}{2}$

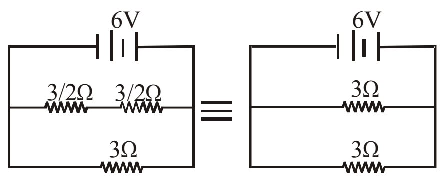
44. **(b)** The network of resistors is a balanced wheatstone bridge. Hence, no current will flow through centre resistor. The equivalent circuit is



$$R_{eq} = \frac{15 \times 30}{15+30} = 10\ \Omega \Rightarrow I = \frac{V}{R} = \frac{5}{10} = 0.5\ \text{A}$$

45. **(a)**





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

46. **(c)** Let R_1 and R_2 be the two given resistances
Resistance of the series combination,
$S = R_1 + R_2$
Resistance of the parallel combination,

$$P = \frac{R_1R_2}{R_1 + R_2}$$

As per question $S = nP$

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

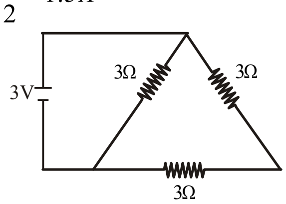
$\Rightarrow (R_1 + R_2)^2 = nR_1R_2$
Minimum value of n is 4 for that
$(R_1 + R_2)^2 = 4R_1R_2$
$\Rightarrow (R_1 - R_2)^2 = 0$

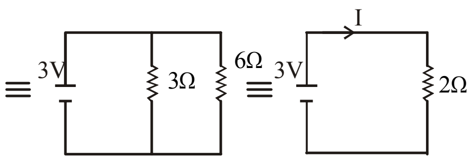
47. **(b)** In the given circuit, resistance of 3Ω is in parallel with series combination of two 3Ω resistance.

$$R_p = \frac{3\times 6}{3+6} = \frac{18}{9} = 2\Omega$$

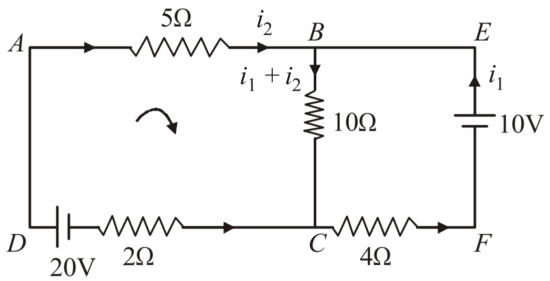
Using ohm's law $V = IR$

$$\Rightarrow I = \frac{V}{R} = \frac{3}{2} = 1.5A$$





48. **(c)**



Using Kirchoff's loop law in loop $ABCD$

$$-5i_2 - 10(i_1 + i_2) - 2i_2 + 20 = 0$$

$$\Rightarrow -10i_1 - 17i_2 + 20 = 0 \quad \text{...(i)}$$

Using Kirchoff's loop law in loop $BEFC$

$$\Rightarrow -10 + 4i_1 + 10(i_1 + i_2) = 0$$

$$\Rightarrow 14i_1 + 10i_2 + 10 = 0 \quad \text{...(ii)}$$

Multiplying equation (i) by 10, we have

$$(10i_1 + 17i_2 = 20) \times 10$$

$$\Rightarrow 100i_1 - 170i_2 = 200 \quad \text{...(iii)}$$

Multiplying equation (ii) by 17, we have

$$(14i_1 + 10i_2 = 10) \times 17$$

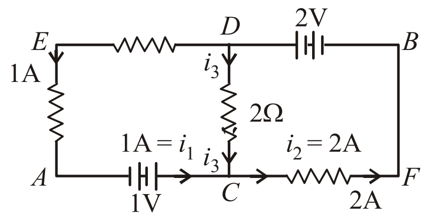
$$\Rightarrow 238i_1 - 170i_2 = 170 \quad \text{...(iv)}$$

On solving equations (iii) and (iv), we get

$$-138i_1 = 30 \Rightarrow i_1 = -\frac{30}{138} = -0.217$$

i_1 is negative it means current flows from positive to negative terminal.

49. **(d)**



Let us assume the potential at $A = V_A = 0$
Using Kirchoff's junction rule at C, we get

$$i_1 + i_3 = i_2$$

$$1A + i_3 = 2\ A \Rightarrow i_3 = 2A$$

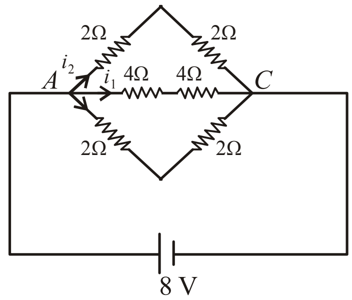
Now using Kirchoff's loop law along $ACDB$

$$V_A + 1 + i_3(2) - 2 = V_B$$

$$\Rightarrow V_A + 1 + i_3(1) - 2 = V_B$$

$$\Rightarrow V_B - V_A = 3 - 2 = 1 \text{ volt}$$

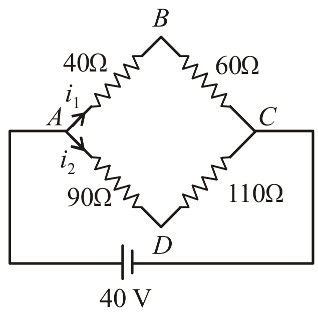
50. **(c)** The equivalent circuit can be drawn as



Voltage across AC = 8 V
Resistance R_{AC} = 4 + 4 = 8 Ω

$$i_1 = \frac{V}{R_{AC}} = \frac{8}{4+4} = 1 \text{ Amp}$$

51. **(2)**



Current through AB, $i_1 = \frac{40}{40+60} = 0.4$

Current through AD, $i_2 = \frac{40}{90+110} = \frac{1}{5}$

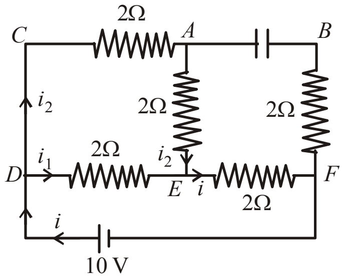
Using KVL in BAD loop

$V_B + i_1(40) - i_2(90) = V_D$

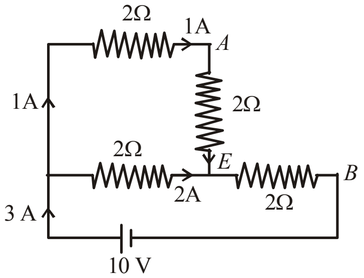
$\Rightarrow V_B - V_D = \frac{1}{5}(90) - \frac{4}{10}(40)$

$\Rightarrow V_B - V_D = 18 - 16 = 2\,\text{V}$

52. **(08.00)**



As capacitor is fully charged no current will flow through it.



We have the current distribution as shown in the figure.

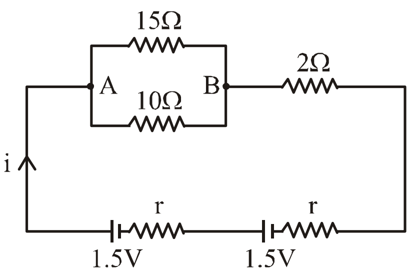
Equivalent resistance, $R_{eq} = \left(\frac{4 \times 2}{4+2}\right) + 2$

Net current, $i = \frac{10}{\frac{4}{3}+2} = \frac{10 \times 3}{10} = 3$ Amp

$i_1 = 2$ A and $i_2 = 1$ A

$V_{AEB} = 1 \times 2 + 3 \times 2 = 8\,\text{V}$

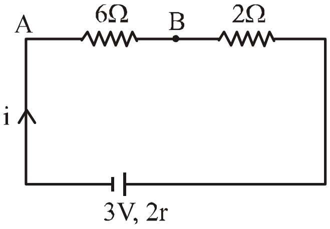
53. **(b)** For the given circuit



$\text{i} = \frac{3}{8+2\text{r}}$

Now voltage across AB

$\text{i} \times 6 = \frac{3}{8+2\text{r}} \times 6 = 2$ $\equiv$

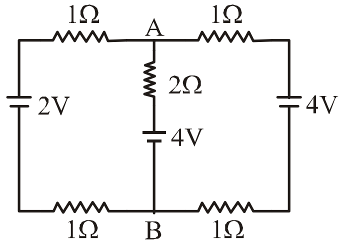


$\Rightarrow 9 = 8 + 2\text{r}$

$\Rightarrow \text{r} = \frac{1}{2}\Omega$

54. **(d)** Applying parallel combination of batteries

$$\frac{\frac{E_1}{1+1}+\frac{E_2}{2}+\frac{E_3}{1+1}}{\frac{1}{1+1}+\frac{1}{2}+\frac{1}{1+1}}$$



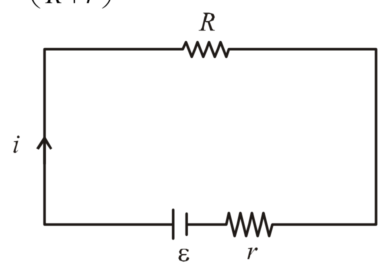
$$\frac{\frac{2}{2}+\frac{4}{2}+\frac{4}{2}}{\frac{1}{2}+\frac{1}{2}+\frac{1}{2}} = \frac{5 \times 2}{3}$$

$= \frac{10}{3} = 3.3$ Volt

55. **(d)** $i = \left(\frac{\varepsilon}{R+r}\right)$

Power delivered to R.

$P = i^2 R = \left(\frac{\varepsilon}{R+r}\right)^2 R$

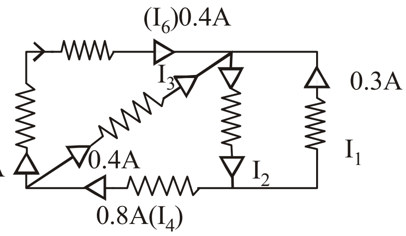


P to be maximum, $\frac{dP}{dR} = 0$

or $\frac{d}{dR}\left[\left(\frac{\varepsilon}{R+r}\right)^2 R\right] = 0$

or $R = r$

56. **(b)**



From KCL, $I_3 = 0.8 - 0.4 = 0.4\,\text{A}$

$I_2 = 0.4 + 0.4 + 0.3$

$= 1.1$ A

and $I_6 = 0.4\,\text{A}$

57. **(b)** Given, $E_1 = 1\text{V}, E_2 = 2\text{V}, E_3 = 3\text{V}, r_1 = 1\Omega,$ $r_2 = 1\Omega$ and $r_3 = 1\Omega$

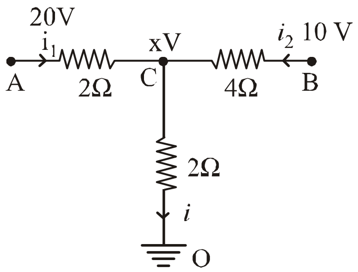
$$V_{AB}=V_{CD}=\frac{\frac{E_1}{r_1}+\frac{E_2}{r_2}+\frac{E_3}{r_3}}{\frac{1}{r_1}+\frac{1}{r_2}+\frac{1}{r_3}}=\frac{\frac{1}{1}+\frac{2}{1}+\frac{3}{1}}{\frac{1}{1}+\frac{1}{1}+\frac{1}{1}}=\frac{6}{3}=2V$$

58. **(c)** Current passing through resistance R_1,

$$i_1=\frac{v}{R_1}=\frac{10}{20}=0.5A$$

and, $i_2=0$

59. **(b)**

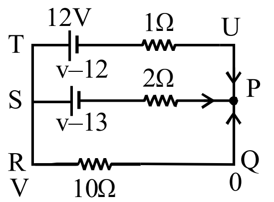


Let voltage at C = xV
From kirchhoff's current law,
KCL : $i_1+i_2=i$

$$\frac{20-x}{2}+\frac{10-x}{4}=\frac{x-0}{2}\Rightarrow x=10$$

$$\therefore i=\frac{V}{R}=\frac{X}{R}=\frac{10}{2}=5A$$

60. **(b)**



Using Kirchhoff's law at *P* we get

$$\frac{V-12}{1}+\frac{V-13}{2}+\frac{V-0}{10}=0$$

[Let potential at P, Q, U = 0 and at R = V

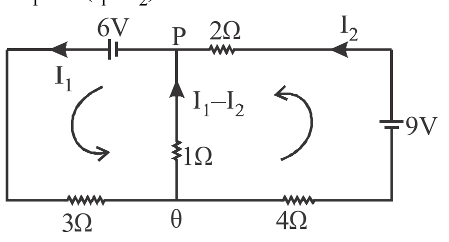
$$\Rightarrow \frac{V}{1}+\frac{V}{2}+\frac{V}{10}=\frac{12}{1}+\frac{13}{2}+\frac{0}{10}$$

$$\Rightarrow \frac{10+5+1}{10}V=\frac{24+13}{2}\Rightarrow V\left(\frac{16}{10}\right)=\frac{37}{2}$$

$$\Rightarrow V=\frac{37\times10}{16\times2}=\frac{370}{32}=11.56\text{ volt}$$

61. **(a)** From KVL

$-6+3I_1+1\,(I_i-I_2)=0$



$6=3\,I_1+I_1-I_2;\ 4I_1-I_2=6$ ...(1)

$-9+2I_2-(I_1-I_2)+3I_2=0$

$-I_1+6I_2=9$ ...(2)

On solving (1) and (2)

$I_1=0.13A$

Direction Q to P, since $I_1>I_2$.

62. **(c)** As no current flows through arm *EB* then

$V_D=0V$

$V_E=0V$

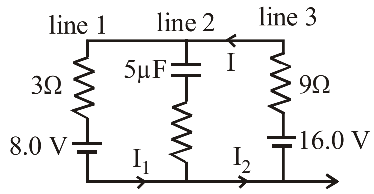
$V_B=-4V$

$V_A=5V$

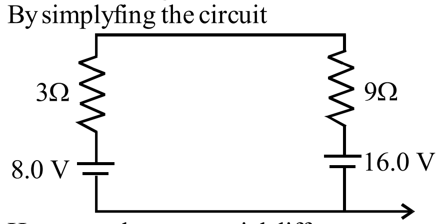
So, potential difference between the points *A* and *D*

$V_A-V_D=5V$

63. **(b)**



In steady state capacitor is fully charged hence no current will flow through line 2.
By simplyfing the circuit



Hence resultant potential difference across resistances will be 8.0 V.

Thus current $I=\frac{V}{R}$

$$=\frac{8.0}{3+9}=\frac{8}{12}$$

or, $I=\frac{2}{3}=0.67\text{ A}$

64. **(a)** Current through 50 V and 30 V batteries are respectively 2.5 A and 3 A.

65. **(c)** Given, emf of cell E = 200 V
Internal resistance of cells = 1 Ω
D. C. main supply voltage V = 220 V
External resistance R = ?

$$r=\left(\frac{E-V}{V}\right)R$$

$$1=\left(\frac{20}{220}\right)\times R\qquad \therefore R=11\,\Omega.$$

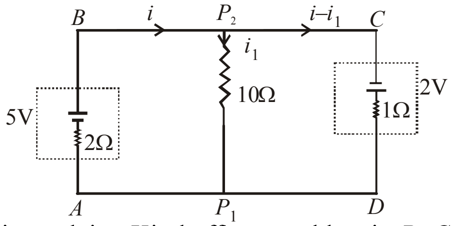
66. **(c)** $\frac{100}{R+r}=\frac{90}{R}\Rightarrow\frac{R+r}{R}=\frac{10}{9}\Rightarrow 1+\frac{0.5}{R}=\frac{10}{9}$

$$\Rightarrow\frac{0.5}{R}=\frac{1}{9}\ \therefore\ R=4.5\,\Omega$$

67. **(c)** Applying Kirchoff's second law in ABP_2P_1A, we get

$-2i+5-10\,i_1=0$

$2i+10i_1=5$ .....(i)



Again applying Kirchoff's second law in $P_2CDP_1P_2$ we get,

$10i_1 + 2 - i + i_1 = 0$

$2_i - 22i_1 = 4$ ....(ii)

From (i) and (ii)

$32i_1 = 1$

$\Rightarrow i_1 = \frac{1}{32}$ A from P_2 to P_1

68. **(a)** Energy in capacitor $= \frac{1}{2}CV^2$

Work done by battery $= QV = CV^2$

where C = Capacitance of capacitor

V = Potential difference,

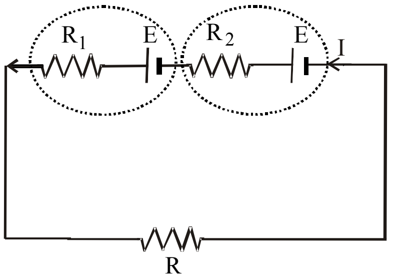
e = emf of battery

Required ratio $= \frac{\frac{1}{2}CV^2}{CV^2} = \frac{1}{2}$ $(\because V = e)$

69. **(d)** **Note :** Kirchhoff's first law is based on conservation of charge and Kirchhoff's second law is based on conservation of energy.

70. **(d)** At cold junction, current flows from Antimony to Bismuth because current flows from metal occurring later in the series to metal occurring earlier in the thermoelectric series. In thermoelectric series, Bismuth comes earlier than Antimony so at cold junction, current. Flow from Antimony to Bismuth.

71. **(a)**



Let E be the emf of each source of current

Current in the circuit $I = \frac{2E}{R + R_1 + R_2}$

Potential difference across cell having internal resistance R_2

$V = E - iR_2 = 0$

$E - \frac{2E}{R + R_1 + R_2} \cdot R_2 = 0$

$\Rightarrow R + R_1 + R_2 - 2R_2 = 0$

$\Rightarrow R + R_1 - R_2 = 0$

$\Rightarrow R = R_2 - R_1$

72. **(a)** From Faraday's first law of electrolysis, mass deposited

$m = Zq$

$\Rightarrow Z \propto \frac{1}{q} \Rightarrow \frac{Z_1}{Z_2} = \frac{q_2}{q_1}$ .... (i)

Also $q = q_1 + q_2$ .... (ii)

$\Rightarrow \frac{q}{q_2} = \frac{q_1}{q_2} + 1$ (Dividing (ii) by q_2)

$\Rightarrow q_2 = \frac{q}{1 + \frac{q_1}{q_2}}$ .... (iii)

From equation (i) and (iii),

$q_2 = \frac{q}{1 + \frac{Z_2}{Z_1}}$

73. **(d)** Current is given by

$I = \frac{E}{R + r}$,

If internal resistance (r) is zero,

$I = \frac{E}{R}$ = constant.

Thus, energy source will supply a constant current if its internal resistance is zero.

74. **(d)** Given $E = a\theta + b\theta^2$

$\Rightarrow \frac{dE}{d\theta} = a + 2b\theta$

At neutral temperature

$\theta = \theta_n : \frac{dE}{d\theta} = 0$

$\Rightarrow \theta_n = \frac{-a}{2b} = -350 \Rightarrow \frac{d^2E}{d\theta^2} = 2b$

hence no θ is possible for E to be maximum no neutral temperature is possible.

75. **(c)** From the Faraday's first law of electrolysis,

$m = Zit$

$\Rightarrow m = 3.3 \times 10^{-7} \times 3 \times 2$

$= 19.8 \times 10^{-7}$ kg

76. **(a)** Let the smallest temperature difference be θ°C that can be detected by the thermocouple, then

Thermo emf $= (25 \times 10^{-6})\,\theta$

Let I is the smallest current which can be detected by the galvanometer of resistance R.

Potential difference across galvanometer

$IR = 10^{-5} \times 40$

$\therefore 10^{-5} \times 40 = 25 \times 10^{-6} \times \theta$

$\Rightarrow \theta = 16°C$.

77. **(c)** According to Faraday's first law of electrolysis

$m = Z \times I \times t$

When I and t is same, $m \propto Z$

$\therefore \frac{m_{Cu}}{m_{Zn}} = \frac{Z_{Cu}}{Z_{Zn}} \Rightarrow m_{Cu} = \frac{Z_{Cu}}{Z_{Zn}} \times m_{Zn}$

$\Rightarrow m_{Cu} = \frac{31.5}{32.5} \times 0.13 = 0.126$ g

78. **(b)** From the Faraday's first law of electrolysis
$m = ZIt \Rightarrow m \propto It$

79. **(b)** Given : Power, $P = 1$ kW = 1000 W

$R = 2\Omega,\ V = 220\,\text{V}$

$$\text{Current, } I = \frac{P}{V} = \frac{1000}{220}$$

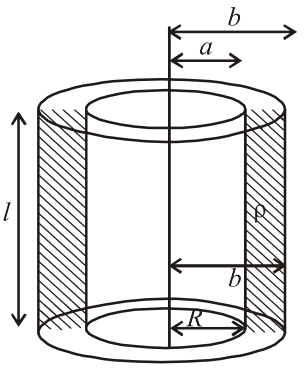
$$P_{\text{loss}} = I^2R = \left(\frac{1000}{220}\right)^2 \times 2$$

$$\therefore \text{Efficiency} = \frac{1000}{1000 + P_{\text{loss}}} \times 100 = 96\%.$$

80. **(b)** Maximum power in external resistance is generated when it is equal to internal resistance of battery i.e., P_R maximum when $r = R$

The maximum Joule heating in R will take place for, the resistance of small element

$$\Delta R = \frac{\rho dr}{2\pi rl} \Rightarrow R = \frac{\rho}{2\pi l}\int_a^b \frac{dr}{r}$$



$$\text{or, } R = \frac{\rho}{2\pi l}\ln\frac{b}{a}$$

81. **(d)** Net Power, P
$= 15 \times 45 + 15 \times 100 + 15 \times 10 + 2 \times 1000$
$= 15 \times 155 + 2000$ W
Power, $P = VI$

$$\Rightarrow \quad I = \frac{P}{V}$$

$$\therefore \quad I_{\text{main}} = \frac{15 \times 155 + 2000}{220} = 19.66\ A \approx 20A$$

82. **(b)** Equivalent resistance,

$$R_{\text{eq}} = \frac{4R \times 4R}{4R + 4R} + R + \frac{6R \times 12R}{6R + 12R} + R$$
$= 2R + R + 4R + R$
$= 8R.$

$$\text{Using, } P = \frac{V^2}{R_{\text{eq}}} \Rightarrow 4 = \frac{16^2}{8R}$$

$$\therefore \quad R = \frac{16^2}{4 \times 8} = 8\,\Omega$$

83. **(b)**

84. **(a)** As $R = \frac{V^2}{P}$, so $R_1 = \frac{220^2}{25}$ and $R_2 = \frac{220^2}{100}$

$$\text{Current flown i} = \frac{220}{R_1 + R_2}$$

$$P_1 = i^2R_1 = \frac{220^2}{\left(\frac{220^2}{25} + \frac{220^2}{100}\right)} \times \frac{220^2}{25} = 16\text{ W}$$

Similarly, $P_2 = i^2R_2 = 4$ W

85. **(b)** When two resistances are connected in series, $R_{eq} = 2R$

$$\text{Power consumed, } P = \frac{\varepsilon^2}{R_{eq}} = \frac{\varepsilon^2}{2R}$$

In parallel condition, $R_{eq} = R/2$.

$$\text{New power, } P' = \frac{\varepsilon^2}{(R/2)}$$

or $P' = 4P = 240$ W ($\because$ P = 60 W)

86. **(a)** Colour code for carbon resistor

Bl,	Br,	R,	O,	Y,	G	Blue,	V,	Gr,	W
0	1	2	3	4	5	6	7	8	9

Resistance, R = AB × C ± D
$\therefore$ Resistance, $R = 50 \times 10^2\Omega$
Now using formula, Power, $P = i^2R$

$$\therefore i = \sqrt{\frac{P}{R}} = \sqrt{\frac{2}{50 \times 10^2}} = 20\text{mA}$$

87. **(a)** Power, $P = I^2R$
$4.4 = 4 \times 10^{-6} \times R$
$\Rightarrow R = 1.1 \times 10^6\Omega$
When supply of 11 v is connected

$$\text{Power, P'} = \frac{v^2}{R} = \frac{11^2}{1.1} \times \frac{11^2}{1.1} \times 10^{-6}$$

$= 11 \times 10^{-5}$ W

88. **(a)** Rate of heat i.e., Power developed in the wire =

$$P = \frac{V^2}{R}$$

$$\text{Resistance of the wire of length, } L\ R_1 = \frac{\rho L}{A} = \frac{\rho L}{\pi r^2}$$

$$\therefore \quad \text{Power, } P_1 = \frac{V^2}{R_1}$$

Resistance of the wire when length is halved i.e., $L/2$

$$R_2 = \frac{\rho\frac{L}{2}}{\pi(2r)^2} = \frac{\rho L}{\pi 8r^2} = \frac{R_1}{8}$$

$$\therefore \quad \text{Power, } P_2 = \frac{V}{\frac{R_1}{8}} = \frac{8V}{R_1}$$

or, $P_2 = 8P_1$ i.e., power increased 8 times of previous or original wire.

89. **(c)** From the given circuit, net resistances
$R_I = 1\ \Omega, R_{II} = 1/2\ \Omega, R_{III} = 3/2\ \Omega$
It is clear that $R_3 > R_1 > R_2$
Hence, $P_3 < P_1 < P_2$

As Power (P) $= \frac{V^2}{R} \Rightarrow P \propto \frac{1}{R}$

90. **(None)** Work done in 30s, $W = \int_0^{30} \frac{V^2}{R} dt$

or, $W = \int_0^{30} \frac{(200)^2}{100(1+\alpha\frac{20t}{3})} dt = \frac{(200)^2}{100}\int_0^{30} \frac{dt}{1+\frac{20\alpha}{3}t}$

$= \frac{400\times 3}{20\alpha}\ell n\left(\frac{\frac{1+20\alpha}{3}\times 30}{1}\right) = 60{,}000\ \ell n\left(\frac{6}{5}\right)$

$\because\ 120 = 100\left[1+\alpha(200)\right]$

$\therefore\ \alpha = \frac{1}{1000}$

91. **(c)** Heat energy will be maximum when resistance will be minimum.

92. **(c)** Total power consumed by electrical appliances in the building, $P_{total} = 2500W$
Watt = Volt × ampere
$\Rightarrow\ 2500 = V\times I \Rightarrow 2500 = 220\,I$

$\Rightarrow\ I = \frac{2500}{220} = 11.36 \approx 12A$

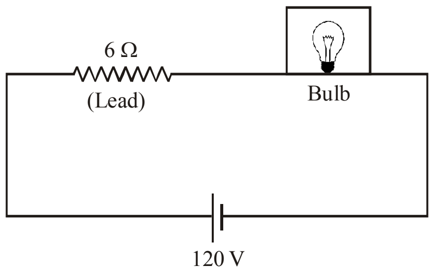
(Minimum capacity of main fuse)

93. **(c)** Current in each bulb $= \frac{\text{Power}}{\text{Voltage}}$

$= \frac{100}{220} = 0.45A$

Current through ammeter = 0.45 × 3 = 1.35 A

94. **(d)**



Power of bulb = 60 W (given)

Resistance of bulb $= \frac{120\times 120}{60} = 240\Omega$

$\left[\because\ P = \frac{V^2}{R}\right]$

Power of heater = 240W (given)

Resistance of heater $= \frac{120\times 120}{240} = 60\Omega$

Voltage across bulb before heater is switched on,

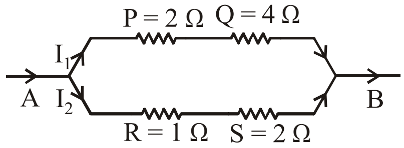
$V_1 = \frac{240}{246}\times 120 = 117.73$ volt

Voltage across bulb after heater is switched on,

$V_2 = \frac{48}{54}\times 120 = 106.66$ volt

Hence decrease in voltage
$V_1 - V_2 = 117.073 - 106.66 = 10.04$ Volt (approximately)

95. **(b)**



$R_1 = P + Q = 2\ \Omega + 4\ \Omega = 6\ \Omega$

$R_2 = R + S = 1\Omega + 2\ \Omega = 3\ \Omega$

$I_1R_1 = I_2R_2$

$I_1 = \frac{R_2}{R_1}I_2 = \frac{3}{6}I_2 = \frac{I_2}{2}$

or $I_2 = 2I_1$
Heat flow $H = I^2 Rt$

For Q, $H_Q = I_1^2\, Qt = \frac{I_2^2}{4}\times 4t = I_2^2 t$

For S, $H_S = I_2^2\, St = I_2^2\cdot 2t = 2I_2^2 t$

$\therefore$ Greatest amount of heat generated by S.

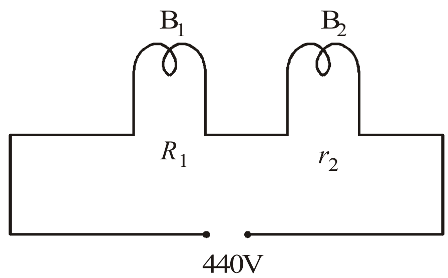
96. **(c)** Current capacity of 25 W bulb

$I_1 = \frac{W_1}{V_1} = \frac{25}{220}$ Amp

Current capacity of 100 W bulb

$I_2 = \frac{W_2}{V_2} = \frac{100}{220}$ Amp

The current flowing through the circuit



Resistance of 25 W bulb,

$R_1 = \frac{V_1^2}{P_1} = \frac{(220)^2}{25}$;

Resistance of 100 W bulb

$R_2 = \frac{V_2^2}{P} = \frac{(220)^2}{100}$

$R_{eff} = R_1 + R_2$
Current flowing through circuit

$I = \frac{440}{R_{eff}}$

$I = \frac{440}{\frac{(220)^2}{25} + \frac{(220)^2}{100}}$

$= \frac{440}{(220)^2\left[\frac{1}{25} + \frac{1}{100}\right]}$; $\quad I = \frac{40}{220}$ Amp

$\because I_1\left(=\frac{25}{220}A\right) < I\left(=\frac{40}{220}A\right) < I_2\left(=\frac{100}{200}A\right)$

Thus the bulb rated 25 W–220 will fuse.

97. **(b)** Total resistance $= \frac{6\times 3}{6+3} = 2\Omega$

Current in circuit $= \frac{6}{2} = 3A$

Therefore current through bulb 1 is $2A$ and bulb 2 is $1A$. So bulb 1 will glow more

98. **(c)** Resistors 4 Ω, 6 Ω and 12 Ω are connected in parallel, its equivalent resistance (R) is given by

$\frac{1}{R} = \frac{1}{4} + \frac{1}{6} + \frac{1}{12} \Rightarrow R = \frac{12}{6} = 2\Omega$

Again R is connected to 1.5 V battery whose internal resistance $r = 1\ \Omega$.

Equivalent resistance now,

$R' = 2\Omega + 1\Omega = 3\Omega$

Current, $I_{total} = \frac{V}{R'} = \frac{1.5}{3} = \frac{1}{2}$ A

$I_{total} = \frac{1}{2} = 3x + 2x + x = 6x$

$\Rightarrow x = \frac{1}{12}$

$\therefore$ Current through 4Ω resistor $= 3x$

$= 3 \times \frac{1}{12} = \frac{1}{4}A$

Therefore, rate of Joule heating in the 4Ω resistor

$= I^2R = \left(\frac{1}{4}\right)^2 \times 4 = \frac{1}{4} = 0.25\text{W}$

99. **(c)**

100. **(b)** Let resistance of bulb filament be R_0 at 0°C using $R = R_0(1 + \alpha\,\Delta t)$ we have

$R_1 = R_0[1 + \alpha \times 100] = 100$ ....(1)

$R_2 = R_0[1 + \alpha \times T] = 200$ ....(2)

On dividing we get

$\frac{200}{100} = \frac{1+\alpha T}{1+100\alpha} \Rightarrow 2 = \frac{1+0.005T}{1+100\times 0.005}$

$\Rightarrow T = 400°\text{C}$

Note : We may use this expression as an approximation because the difference in the answers is appreciable. For accurate results one should use $R = R_0 e^{\alpha\Delta T}$

101. **(c)** The resistance of the electric bulb is

$R = \frac{V^2}{P} = \frac{(220)^2}{100}$

The power consumed when operated at 110 V is

$P' = \frac{V^2}{R}$

$\Rightarrow P = \frac{(110)^2}{(220)^2/100} = \frac{100}{4} = 25\ \text{W}$

102. **(b)** Heat generated,

$H = \frac{V^2 t}{R}$

After cutting equal length of heater coil will become half. As $R \propto \ell$

Resistance of half the coil $= \frac{R}{2}$

$H' = \frac{V^2 t}{\frac{R}{2}} = 2H$

$\therefore$ As R reduces to half, 'H' will be doubled.

103. **(b)** Power, $P = Vi = \frac{V^2}{R}$

$\therefore$ Resistance of tungsten filament when in use

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

Resistance when not in use *i.e.*, cold resistance

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

104. **(a)** Thermistors are usually made of metaloxides with high temperature coefficient of resistivity.

105. **(a)** Heat supplied in time t for heating 1L water from 10°C to 40°C

$\Delta Q = mC_p \times \Delta T$

$= 1 \times 4180 \times (40 - 10) = 4180 \times 30$

But $\Delta Q = P \times t = 836 \times t$

$\Rightarrow t = \frac{4180\times 30}{836} = 150\text{s}$

106. **(c)** We know that resistance,

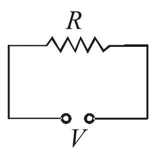
$R = \frac{V_{rated}^2}{P_{rated}} = \frac{(220)^2}{1000} = 48.4\,\Omega$

When this bulb is connected to 110 volt mains supply we get

$P = \frac{V^2}{R} = \frac{(110)^2}{48.4} = 250\text{W}$

107. **(b)** **Case 1** Initial power dissipation,

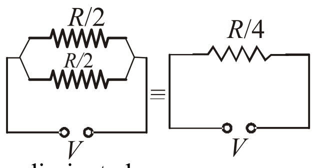
$P_1 = \frac{V^2}{R}$



Case 2

When wire is cut into two equal pieces, the resistance of each piece is $\frac{R}{2}$. When they are connected in parallel

Equivalent resistance, $R_{eq} = \frac{R/2}{2} = \frac{R}{4}$



Power dissipated,

$$P_2 = \frac{V^2}{R/4} = 4\left(\frac{V^2}{R}\right) = 4P_1$$

108. (b) The equivalent resistance of parallel combination of 2Ω and R is

$$R_{eq} = \frac{2 \times R}{2 + R}$$

$\therefore$ Power dissipation $P = \frac{V^2}{R_{eq}}$ $\quad \therefore 150 = \frac{(15)^2}{R_{eq}}$

$$\Rightarrow 150 = \frac{225 \times (R+2)}{2R} \Rightarrow \frac{2R}{2+R} = \frac{3}{2}$$

$\Rightarrow 4R = 6 + 3R \Rightarrow R = 6\Omega$

109. (d) The voltmeter of resistance $10k\Omega$ is parallel to the resistance of 400Ω. So, their equivalent resistance is

$$\frac{1}{R'} = \frac{1}{10\,k\Omega} + \frac{1}{400\Omega} = \frac{1}{10000} + \frac{1}{400}$$

$$\Rightarrow \frac{1}{R'} = \frac{1+25}{10000} = \frac{26}{10000}$$

$$\Rightarrow R' = \frac{10000}{26}\Omega$$

Using Ohm's law, current in the circuit

$$I = \frac{\text{Voltage}}{\text{Net Resistance}} = \frac{6}{\frac{10000}{26} + 800}$$

Potential difference measured by voltmeter

$$V = IR' = \frac{6}{\frac{10000}{26} + 800} \times \frac{10000}{26}$$

$$\Rightarrow V = \frac{150}{77} = 1.95 \text{ volt}$$

110. (b) Multimeter shows deflection in both cases i.e. before and after reversing the probes if the chosen component is capacitor.

111. (a) Potential gradient, $x = \frac{\text{Potential drop}}{\text{length}}$

Here, Potential drop = 1.02

Balancing length from P = 100 – 49

$$\therefore x = \frac{1.02}{100 - 49} = 0.02 \text{ volt/cm}$$

112. (40) For the given meter bridge

$\frac{R}{S} = \frac{\ell_1}{100 - \ell_1}$ Where, ℓ_1 = balancing length

$$\Rightarrow \frac{R}{S} = \frac{25}{75} = \frac{1}{3} \qquad ...(i)$$

New resistance,

$$R' = \frac{\rho\frac{\ell}{2}}{\frac{A}{4}} = \rho\frac{\ell \times 2}{A} \qquad \left(\because R = \rho\frac{\ell}{A}\right)$$

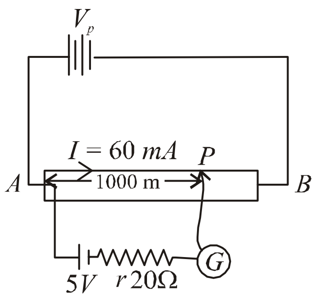
$\Rightarrow R' = 2R$

$$\frac{R'}{S} = \frac{\ell_2}{100 - \ell_2} \Rightarrow \frac{2R}{S} = \frac{\ell_2}{100 - \ell_2}$$

$$\Rightarrow 2 \times \frac{1}{3} = \frac{\ell_2}{100 - \ell_2} \qquad \text{Using (i)}$$

$\Rightarrow \ell_2 = 40$ cm

113. (d)



Let R be the resistance of the whole wire

Potential gradient for the potentiometer wire

$$'AB' = -\frac{dV}{d\ell} = \frac{I \times R}{\ell} = \left[\frac{60 \times R}{\ell_{AB}}\right] mv/m$$

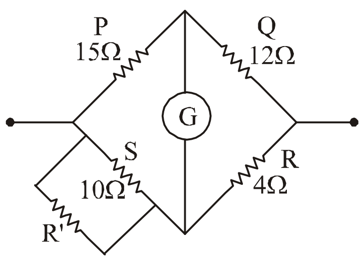
$$V_{AP} = \left(\frac{dV}{d\ell_{AB}}\right)\ell_{AP} = \frac{60 \times R}{1200} \times 1000 mV$$

$\Rightarrow V_{AP} = 50\,R\,mV$

Also, $V_{AP} = 5\,V$ (for balance point at P)

$$\therefore R = \frac{V_{AP}}{50 \times 10^{-3}} = \frac{5}{50 \times 10^{-3}} = 100\Omega$$

114. (10)



As per Wheatstone bridge balance condition $\frac{P}{Q} = \frac{S}{R}$

Let resistance R' is connected in parallel with resistance S of 10Ω

$$\therefore \frac{15}{12} = \frac{\frac{10R'}{10+R'}}{4} \Rightarrow 5 = \frac{10R'}{10+R'}$$

$\Rightarrow 50 + 5R' = 10R'$

$$\therefore R' = \frac{50}{5} = 10\Omega$$

115. (12) We know that

$E \propto \ell$ where l is the balancing length

$\therefore E = k(560)$ ....(i)

When the balancing length changes by 60 cm

$$\frac{E}{r+10}10 = k\ (500) \quad \text{...(ii)}$$

Dividing (i) by (ii) we get

$$\Rightarrow \frac{r+10}{10} = \frac{56}{50} \Rightarrow 50r + 500 = 560$$

$$\Rightarrow r = \frac{6}{5}\Omega = \frac{N}{10}\Omega \Rightarrow N = 12$$

116. (c) For a balanced bridge

$$\frac{R_1}{R_2} = \frac{l_2}{l_1}$$

So $\frac{R}{X} = \frac{l}{100-l}$

Using the above expression

$$X = \frac{R(100-l)}{l}$$

for observation (1) $X = \frac{100 \times 40}{60} = \frac{2000}{3}\Omega$

for observation (2) $X = \frac{100 \times 87}{13} = \frac{8700}{13}\Omega$

for observation (3) $X = \frac{10 \times 98.5}{1.5} = \frac{1970}{3}\Omega$

for observation (4) $X = \frac{1 \times 99}{1} = 99\Omega$

Clearly we can see that the value of x calculated in observation (4) is inconsistent than other.

117. (c) The resistance of potentiometer wire

$$R = 0.01 \times 400 = 4\,\Omega$$

Current in the wire

$$i = \frac{V}{R_T} = \frac{3}{4 + 0.5 + 0.57 + 1} = \frac{1}{2}A$$

Now $V = iR_{AJ} = \frac{1}{2} \times (0.01 \times 50) = 0.25$ V.

118. (c) We have given

$$\frac{dR}{d\ell} \propto \frac{1}{\sqrt{\ell}} \Rightarrow \frac{dR}{d\ell} = k \times \frac{1}{\sqrt{\ell}} \quad \text{(where k is constant)}$$

$$dR = k\frac{d\ell}{\sqrt{\ell}}$$

Let R_1 and R_2 be the resistance of AP and PB respectively. Using wheatstone bridge principle

$$\therefore \frac{R'}{R'} = \frac{R_1}{R_2} \text{ or } R_1 = R_2$$

Now, $\int dR = k\int \frac{d\ell}{\sqrt{\ell}}$

$$\therefore R_1 = k\int_0^{\ell} \ell^{-1/2} d\ell = k.2.\sqrt{\ell}$$

$$R_2 = k\int_{\ell}^{1} \ell^{-1/2} d\ell = k.(2 - 2\sqrt{\ell})$$

Putting $R_1 = R_2$

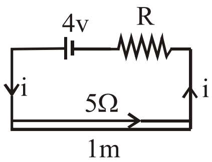
$$k2\sqrt{\ell} = k(2 - 2\sqrt{\ell})$$

$$\therefore 2\sqrt{\ell} = 1$$

$$\sqrt{\ell} = \frac{1}{2}$$

i.e., $\ell = \frac{1}{4}$ m $\Rightarrow$ 0.25 m

119. (c)



Current flowing through the circuit (I) is given by

$$I = \left(\frac{4}{R+5}\right)A$$

Resistance of length 10 cm of wire

$$= 5 \times \frac{10}{100} = 0.5\Omega$$

According to question,

$$5 \times 10^{-3} = \left(\frac{4}{R+5}\right).(0.5)$$

$$\therefore \frac{4}{R+5} = 10^{-2} \text{ or } R + 5 = 400\Omega$$

$\therefore R = 395\Omega$

120. (b) Given, Emf of cell, $\varepsilon = 0.5$ v

Rheostat resistance, $R_h = 2\Omega$

Potential gradient is

$$\frac{dv}{dL} = \left(\frac{6}{2+4}\right) \times \frac{4}{L}$$

Let null point be at ℓ cm when cell of emf $\varepsilon = 0.5$ v is used.

thus $\varepsilon_1 = 0.5V = \left(\frac{6}{2+4}\right) \times \frac{4}{L} \times \ell$ ... (i)

For resistance $R_h = 6\Omega$ new potential gradient is $\left(\frac{6}{4+6}\right) \times \frac{4}{L}$ and at null point

$$\left(\frac{6}{4+6}\right)\left(\frac{4}{L}\right) \times \ell = \varepsilon_2 \qquad \text{... (ii)}$$

Dividing equation (i) by (ii) we get

$$\frac{0.5}{\varepsilon_2} = \frac{10}{6} \text{ thus } \varepsilon_2 = 0.3\text{v}$$

121. (d)

122. (c) Initially at null deflection $\frac{R_1}{R_2} = \frac{2}{3}$ ...(i)

Finally at null deflection, when null point is shifted

$$\frac{R_1+10}{R_2} = 1 \Rightarrow R_1 + 10 = R_2 \quad \text{...(ii)}$$

Solving equations (i) and (ii) we get

$$\frac{2R_2}{3} + 10 = R_2$$

$$10 = \frac{R_2}{3} \Rightarrow R_2 = 30\Omega$$

& $R_1 = 20\Omega$

Now if required resistance is R then

$$\frac{\frac{30 \times R}{30+R}}{30} = \frac{2}{3}$$

$R = 60\Omega$

123. (c) Let x be the length AJ at which galvanometer shows null deflection current,

$$i = \frac{\varepsilon}{12r+r} = \frac{3}{13r} \text{ or, } i\left(\frac{x}{L}12r\right) = \frac{\varepsilon}{2}$$

$$\Rightarrow \frac{\varepsilon}{13r}\left[\frac{x}{L}\cdot 12r\right] = \frac{\varepsilon}{2} \Rightarrow \frac{\varepsilon}{13r}\left[\frac{x}{L}\cdot 12r\right] = \frac{\varepsilon}{2}$$

or, $x = \frac{13L}{24}$

124. (a) Given, colour code of resistance,

R_1 = Orange, Red and Brown

$\therefore R_1 = 32 \times 10 = 320$

using balanced wheatstone bridge principle,

$$\frac{R_1}{R_3} = \frac{R_2}{R_4} \Rightarrow \frac{320}{R_3} = \frac{80}{40}$$

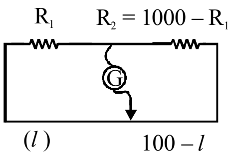
$\therefore R_3 = 160$ i.e. colour code for R_3 Brown, Blue and Brown

125. (b) Using formula, internal resistance,

$$r = \left(\frac{l_1 - l_2}{l_2}\right)s = \left(\frac{52-40}{40}\right) \times 5 = 1.5\Omega$$

126. (c) $R_1 + R_2 = 1000$

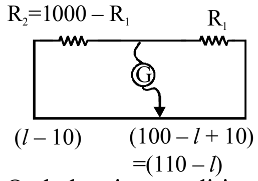
$\Rightarrow R_2 = 1000 - R_1$



On balancing condition

$R_1(100 - l) = (1000 - R_1)l$ ...(i)

On Interchanging resistance balance point shifts left by 10 cm



On balancing condition

$(1000 - R_1)(110 - l) = R_1(l - 10)$

or, $R_1(l - 10) = (1000 - R_1)(110 - l)$ ...(ii)

Dividing eqn (i) by (ii)

$$\frac{100-l}{l-10} = \frac{l}{110-l}$$

$\Rightarrow (100 - l)(110 - l) = l(l - 10)$

$\Rightarrow 11000 - 100l - 110l + l^2 = l^2 - 10l$

$\Rightarrow 11000 = 200l$

or, $l = 55$

Putting the value of 'l' in eqn (i)

$R_1(100 - 55) = (1000 - R_1)55$

$\Rightarrow R_1(45) = (1000 - R_1)55$

$\Rightarrow R_1(9) = (1000 - R_1)11$

$\Rightarrow 20R_1 = 11000$

$\therefore R_1 = 550K\Omega$

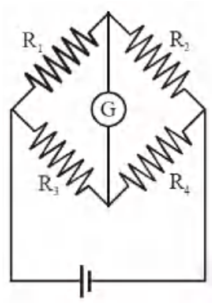
127. (b) For a balanced meter bridge,

$$\frac{X}{39.5} = \frac{Y}{(100-39.5)} \Rightarrow Y = 39.5 = X \times (100 - 39.5)$$

or, $X = \frac{12.5 \times 39.5}{60.5} = 8.16\Omega$

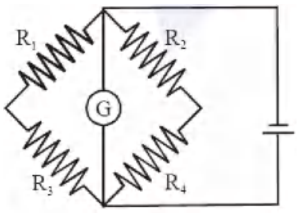
When X and Y are interchanged l_1 and $(100 - l_1)$ will also interchange so, $l_2 = 60.5$ cm

128. (d) There is no change in null point, if the cell and the galvanometer are exchanged in a balanced wheatstone bridge.



On balancing condition $\frac{R_1}{R_3} = \frac{R_2}{R_4}$

After exchange



On balancing condition $\frac{R_1}{R_2} = \frac{R_3}{R}$

129. **(d)** In balance position of bridge, $\frac{P}{Q} = \frac{l}{(100-l)}$

Initially neutral position is 60 cm. from A, so

$$\frac{4}{60} = \frac{Q}{40} \Rightarrow Q = \frac{16}{6} = \frac{8}{3}\Omega$$

Now, when unknown resistance R is connected in series to P, neutral point is 80 cm from A then,

$$\frac{4+R}{80} = \frac{Q}{20}$$

$$\frac{4+R}{80} = \frac{8}{60}$$

$$R = \frac{64}{6} - 4 = \frac{64-24}{6} = \frac{40}{6}\Omega$$

Hence, the value of unknown resistance R is $= \frac{20}{3}\Omega$

130. **(d)** When key is at point (1)

$V_1 = iR_1 = xl_1$

When key is at (3)

$V_2 = i(R_1 + R_2) = xl_2$

$$\frac{R_1}{R_1+R_2} = \frac{l_1}{l_2} \Rightarrow \frac{R_1}{R_2} = \frac{l_1}{l_2 - l_1}$$

131. (c) As the two cells oppose each other hence, the effective emf in closed circuit is 15 – 10 = 5 V and net resistance is 1 + 0.6 = 1.6 Ω (because in the closed circuit the internal resistance of two cells are in series. Current in the circuit,

$$I = \frac{\text{effective emf}}{\text{total resistance}} = \frac{5}{1.6}A$$

The potential difference across voltmeter will be same as the terminal voltage of either cell.

Since the current is drawn from the cell of 15 V

$\therefore \quad V_1 = E_1 - Ir_1$

$$= 15 - \frac{5}{1.6} \times 0.6 = 13.1\text{ V}$$

132. **(c)** Balancing length l will give emf of cell

$\therefore E = Kl$

Here K is potential gradient.

If the cell is short circuited by resistance 'R'

Let balancing length obtained be l' then

$V = kl'$

$$r = \left(\frac{E-V}{V}\right)R$$

$\Rightarrow \quad V = E - V \quad [\because r = R \text{ given}]$

$\Rightarrow \quad 2V = E$

or, $\quad 2Kl' = Kl$

$\therefore \quad l' = \frac{l}{2}$

133. **(c)** To measure the emf of a cell we prefer potentiometer rather than voltmeter because

(i) the length of potentiometer which allows greater precision.

(ii) in case of potentiometer, no current flows through the cell.

(iii) of high sensitivity.

134. **(a)** Bridge wire in a sensitive meter bridge wire should be of high resistivity and low temperature coefficient.

135. **(c)** From question, $\frac{x}{y} = \frac{40}{100-40} = \frac{2}{3}$

$$\Rightarrow x = \frac{2}{3}y$$

Again, $\frac{3x}{y} = \frac{Z}{100-Z}$

or $\quad \frac{3 \times \frac{2y}{3}}{y} = \frac{Z}{100-Z}$

Solving we get Z = 67 cm

Therefore new position of null point ≅ 67 cm

136. **(c)** Potential gradient

$$\Rightarrow k = \frac{V}{\ell} = \frac{IR}{\ell} = \frac{I}{\ell}\left(\frac{\rho\ell}{A}\right) = \frac{I\rho}{A}$$

$$k = \frac{0.2 \times 4 \times 10^{-7}}{8 \times 10^{-7}} = \frac{0.8}{8} = 0.1\text{ V/m}$$

137. **(b)** Given,

Balance point from one end, $\ell_1 = 20$ cm

From the condition for balance of metre bridge, we have

$$\frac{55}{R} = \frac{\ell_1}{100-\ell_1}$$

$$\frac{55}{R} = \frac{20}{80}$$

$$\Rightarrow R = 220\Omega$$

138. **(b)** From balanced wheat stone bridge $\frac{P}{Q} = \frac{R}{S}$ where

$$S = \frac{S_1 S_2}{S_1 + S_2}$$

139. **(c)** Initial balancing length, $\ell_1 = 240$ cm New balancing length, $\ell_2 = 120$ cm.

The internal resistance of the cell,

$$r = \left(\frac{\ell_1 - \ell_2}{\ell_2}\right) \times R = \frac{240-120}{120} \times 2 = 2\Omega$$

140. **(c)** From the balanced wheat stone bridge

$$\frac{R_1}{R_2} = \frac{\ell_1}{\ell_2}$$

where $\ell_2 = 100 - \ell_1$

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

$Y = 4X$

In the second case

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

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

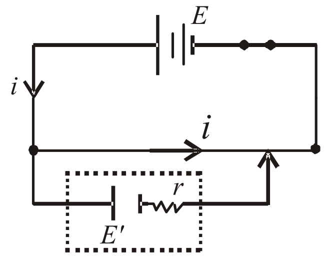
$\Rightarrow \ell = 50$

141. **(d)** From the principle of potentiometer, $V \propto l$

If a cell of emF E is employed in the circuit between the ends of potentiometer wire of length L, then

$$\frac{V}{E} = \frac{l}{L};$$

$$\Rightarrow V = \frac{El}{L} = \frac{30E}{100}$$



Note : In this arrangement, the internal resistance of the battery E does not play any role as current is not passing through the battery.

142. **(d)** $i_g \times G = (i - i_g) S$

$$\therefore S = \frac{i_g \times G}{i - i_g} = \frac{1 \times 0.81}{10 - 1} = 0.09\Omega$$

143. **(c)** To use an ammeter in place of voltmeter, we must connect a high resistance in series with the ammeter. Connecting high resistance in series makes its resistance much higher.