CHAPTER 3

Current Electricity

3.2 Electric Current

1. A flow of 10^7 electrons per second in a conducting wire constitutes a current of
   (a) 1.6×10^{-12} A (b) 1.6×10^{26} A
   (c) 1.6×10^{-26} A (d) 1.6×10^{12} A *(1994)*

3.4 Ohm's Law

2. The resistance of a wire is 'R' ohm. If it is melted and stretched to 'n' times its original length, its new resistance will be
   (a) $\frac{R}{n}$ (b) n^2R
   (c) $\frac{R}{n^2}$ (d) nR *(NEET 2017)*

3. A wire of resistance 4 Ω is stretched to twice its original length. The resistance of stretched wire would be
   (a) 8 Ω (b) 16 Ω
   (c) 2 Ω (d) 4 Ω *(NEET 2013)*

4. A wire of a certain material is stretched slowly by ten percent. Its new resistance and specific resistance become respectively
   (a) both remain the same
   (b) 1.1 times, 1.1 times
   (c) 1.2 times, 1.1 times
   (d) 1.21 times, same *(2008)*

5. The electric resistance of a certain wire of iron is R. If its length and radius are both doubled, then
   (a) The resistance will be doubled and the specific resistance will be halved
   (b) The resistance will be halved and the specific resistance will remain unchanged
   (c) The resistance will be halved and the specific resistance will be doubled
   (d) The resistance and the specific resistance, will both remain unchanged. *(2004)*

6. A 6 volt battery is connected to the terminals of a three metre long wire of uniform thickness and resistance of 100 ohm. The difference of potential between two points on the wire separated by a distance of 50 cm will be
   (a) 2 volt (b) 3 volt
   (c) 1 volt (d) 1.5 volt *(2004)*

7. Three copper wires of lengths and cross-sectional areas (l, A), $(2l, A/2)$ and $(l/2, 2A)$. Resistance is minimum in
   (a) wire of cross-sectional area $2A$
   (b) wire of cross-sectional area $\frac{A}{2}$
   (c) wire of cross-sectional area A
   (d) same in all three cases. *(1997)*

8. A wire 50 cm long and 1 mm² in cross-section carries a current of 4 A when connected to a 2 V battery. The resistivity of the wire is
   (a) 4×10^{-6} Ω m (b) 1×10^{-6} Ω m
   (c) 2×10^{-7} Ω m (d) 5×10^{-7} Ω m *(1994)*

9. The masses of the wires of copper is in the ratio of 1 : 3 : 5 and their lengths are in the ratio of 5 : 3 : 1. The ratio of their electrical resistance is
   (a) 1 : 3 : 5 (b) 5 : 3 : 1
   (c) 1 : 25 : 125 (d) 125 : 15 : 1 *(1988)*

3.5 Drift of Electrons and the Origin of Resistivity

10. A charged particle having drift velocity of 7.5×10^{-4} m s^{-1} in an electric field of 3×10^{-10} V m^{-1}, has a mobility in m^2 V^{-1} s^{-1} of
   (a) 2.25×10^{15} (b) 2.5×10^{6}
   (c) 2.5×10^{-6} (d) 2.25×10^{-15}
   (NEET 2020)

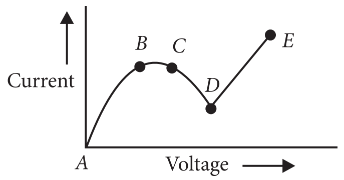
11. The mean free path of electrons in a metal is 4×10^{-8} m. The electric field which can give on an average 2 eV energy to an electron in the metal will be in units V/m
   (a) 5×10^{-11} (b) 8×10^{-11}
   (c) 5×10^{7} (d) 8×10^{7} *(2009)*

12. The velocity of charge carriers of current (about 1 ampere) in a metal under normal conditions is of the order of
(a) a fraction of mm/sec
(b) velocity of light
(c) several thousand metres/second
(d) a few hundred metres per second *(1991)*

3.6 Limitations of Ohm's Law

13. The resistance of a discharge tube is
(a) non-ohmic (b) ohmic
(c) zero (d) both (b) and (c) *(1999)*

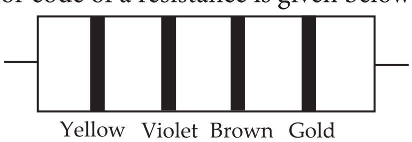
14. From the graph between current (I) and voltage (V) is shown. Identify the portion corresponding to negative resistance



(a) CD (b) DE (c) AB (d) BC *(1997)*

3.7 Resistivity of Various Materials

15. The color code of a resistance is given below



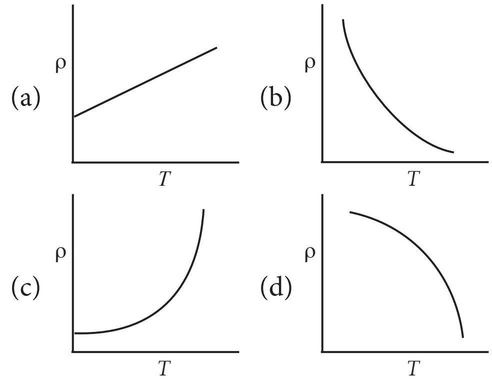
The values of resistance and tolerance, respectively, are
(a) 470 kΩ, 5% (b) 47 kΩ, 10%
(c) 4.7 kΩ, 5% (d) 470 Ω, 5% *(NEET 2020)*

16. A carbon resistor of (47 ± 4.7) kΩ is to be marked with rings of different colours for its identification. The colour code sequence will be
(a) Violet – Yellow – Orange – Silver
(b) Yellow – Violet – Orange – Silver
(c) Yellow – Green – Violet – Gold
(d) Green – Orange – Violet – Gold *(NEET 2018)*

17. Identify the set in which all the three materials are good conductors of electricity.
(a) Cu, Hg and NaCl (b) Cu, Ge and Hg
(c) Cu, Ag and Au (d) Cu, Si and diamond *(1994)*

3.8 Temperature Dependence of Resistivity

18. Which of the following graph represents the variation of resistivity (ρ) with temperature (T) for copper?



(NEET 2020)

19. The solids which have the negative temperature coefficient of resistance are
(a) metals (b) insulators only
(c) semiconductors only
(d) insulators and semiconductors. *(NEET 2020)*

20. Specific resistance of a conductor increases with
(a) increase in temperature
(b) increase in cross-section area
(c) increase in cross-section and decrease in length
(d) decrease in cross-section area. *(2002)*

21. Copper and silicon is cooled from 300 K to 60 K, the specific resistance
(a) decreases in copper but increases in silicon
(b) increases in copper but decreases in silicon
(c) increases in both
(d) decreases in both. *(2001)*

3.9 Electrical Energy, Power

22. Which of the following acts as a circuit protection device?
(a) fuse (b) conductor
(c) inductor (d) switch *(NEET 2019)*

23. The charge flowing through a resistance R varies with time t as $Q = at - bt^2$, where a and b are positive constants. The total heat produced in R is
(a) $\frac{a^3R}{2b}$ (b) $\frac{a^3R}{b}$
(c) $\frac{a^3R}{6b}$ (d) $\frac{a^3R}{3b}$ *(NEET-I 2016)*

24. Two cities are 150 km apart. Electric power is sent from one city to another city through copper wires. The fall of potential per km is 8 volt and the average resistance per km is 0.5 Ω. The power loss in the wire is
(a) 19.2 W (b) 19.2 kW
(c) 19.2 J (d) 12.2 kW *(2014)*

25. If voltage across a bulb rated 220 volt-100 watt drops by 2.5% of its rated value, the percentage of the rated value by which the power would decrease is
(a) 20% (b) 2.5% (c) 5% (d) 10% *(2012)*

26. An electric kettle takes 4 A current at 220 V. How much time will it take to boil 1 kg of water from temperature 20°C ? The temperature of boiling water is 100°C.
(a) 12.6 min (b) 4.2 min
(c) 6.3 min (d) 8.4 min *(2008)*

27. A 5 ampere fuse wire can withstand a maximum power of 1 watt in the circuit. The resistance of the fuse wire is
(a) 0.04 ohm (b) 0.2 ohm
(c) 5 ohm (d) 0.4 ohm *(2005)*

28. In India electricity is supplied for domestic use at 220 V. It is supplied at 110 V in USA. If the resistance of a 60 W bulb for use in India is R, the resistance of a 60 W bulb for use in USA will be
(a) R (b) $2R$
(c) $R/4$ (d) $R/2$ *(2004)*

29. Fuse wire is a wire of
(a) high resistance and high melting point
(b) high resistance and low melting point
(c) low resistance and low melting point
(d) low resistance and high melting point *(2003)*

30. Two bulbs are of (40 W, 200 V), and (100 W, 200 V). Then correct relation for their resistances is
(a) $R_{40} < R_{100}$
(b) $R_{40} > R_{100}$
(c) $R_{40} = R_{100}$
(d) no relation can be predicted. *(2000)*

31. A 5°C rise in temperature is observed in a conductor by passing a current. When the current is doubled the rise in temperature will be approximately
(a) 20°C (b) 16°C
(c) 10°C (d) 12°C *(1998)*

32. A (100 W, 200 V) bulb is connected to a 160 volts supply. The power consumption would be
(a) 100 W (b) 125 W
(c) 64 W (d) 80 W *(1997)*

33. One kilowatt hour is equal to
(a) 36×10^{-5} J (b) 36×10^{-4} J
(c) 36×10^{5} J (d) 36×10^{3} J *(1997)*

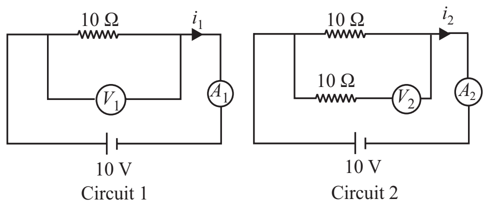
34. A 4 μF capacitor is charged to 400 V. If its plates are joined through a resistance of 2 kΩ, then heat produced in the resistance is
(a) 0.64 J (b) 1.28 J
(c) 0.16 J (d) 0.32 J *(1995)*

35. An electric bulb is rated 60 W, 220 V. The resistance of its filament is
(a) 870 Ω (b) 780 Ω
(c) 708 Ω (d) 807 Ω *(1994)*

36. A current of 2 A, passing through a conductor produces 80 J of heat in 10 seconds. The resistance of the conductor in ohm is
(a) 0.5 (b) 2
(c) 4 (d) 20 *(1989)*

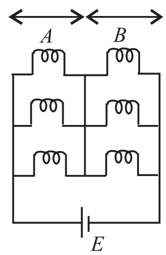
3.10 Combination of Resistors–Series and Parallel

37. In the circuits shown below, the readings of the voltmeters and the ammeters will be



(a) $V_2 > V_1$ and $i_1 > i_2$ (b) $V_2 > V_1$ and $i_1 = i_2$
(c) $V_1 = V_2$ and $i_1 > i_2$ (d) $V_1 = V_2$ and $i_1 = i_2$
(NEET 2019)

38. Six similar bulbs are connected as shown in the figure with a DC source of emf E, and zero internal resistance. The ratio of power consumption by the bulbs when (i) all are glowing and (ii) in the situation when two from section A and one from section B are glowing, will be



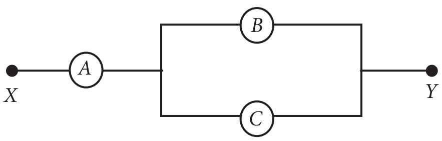
(a) 2 : 1 (b) 4 : 9 (c) 9 : 4 (d) 1 : 2
(NEET 2019)

39. A filament bulb (500 W, 100 V) is to be used in a 230 V main supply. When a resistance R is connected in series, it works perfectly and the bulb consumes 500 W. The value of R is
(a) 230 Ω (b) 46 Ω
(c) 26 Ω (d) 13 Ω *(NEET-II 2016)*

40. Two metal wires of identical dimensions are connected in series. If σ_1 and σ_2 are the conductivities of the metal wires respectively, the effective conductivity of the combination is
(a) $\frac{\sigma_1 + \sigma_2}{\sigma_1 \sigma_2}$ (b) $\frac{\sigma_1 \sigma_2}{\sigma_1 + \sigma_2}$
(c) $\frac{2\sigma_1 \sigma_2}{\sigma_1 + \sigma_2}$ (d) $\frac{\sigma_1 + \sigma_2}{2\sigma_1 \sigma_2}$ *(2015)*

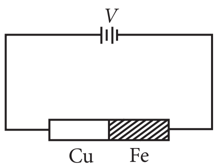
41. A circuit contains an ammeter, a battery of 30 V and a resistance 40.8 ohm all connected in series. If the ammeter has a coil of resistance 480 ohm and a shunt of 20 ohm, the reading in the ammeter will be
(a) 2 A (b) 1 A
(c) 0.5 A (d) 0.25 A *(2015)*

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



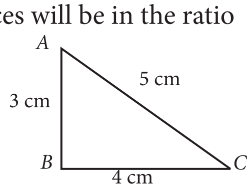
(a) $V_A = V_B \neq V_C$ (b) $V_A \neq V_B \neq V_C$
(c) $V_A = V_B = V_C$ (d) $V_A \neq V_B = V_C$
(2015 Cancelled)

43. Two rods are joined end to end, as shown. Both have a cross-sectional area of 0.01 cm^2. Each is 1 meter long. One rod is of copper with a resistivity of 1.7×10^{-6} ohm-centimeter, the other is of iron with a resistivity of 10^{-5} ohm-centimeter. How much voltage is required to produce a current of 1 ampere in the rods?



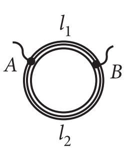
(a) 0.00145 V (b) 0.0145 V
(c) 1.7×10^{-6} V (d) 0.117 V
(Karnataka NEET 2013)

44. A 12 cm wire is given a shape of a right angled triangle ABC having sides 3 cm, 4 cm and 5 cm as shown in the figure. The resistance between two ends (AB, BC, CA) of the respective sides are measured one by one by a multimeter. The resistances will be in the ratio
(a) 9 : 16 : 25
(b) 27 : 32 : 35
(c) 21 : 24 : 25
(d) 3 : 4 : 5



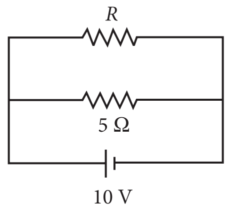
(Karnataka NEET 2013)

45. A ring is made of a wire having a resistance $R_0 = 12\ \Omega$. Find the points A and B, as shown in the figure, at which a current carrying conductor should be connected so that the resistance R of the sub circuit between these points is equal to $\frac{8}{3}\ \Omega$



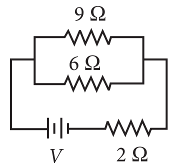
(a) $\frac{l_1}{l_2} = \frac{5}{8}$ (b) $\frac{l_1}{l_2} = \frac{1}{3}$
(c) $\frac{l_1}{l_2} = \frac{3}{8}$ (d) $\frac{l_1}{l_2} = \frac{1}{2}$ *(2012)*

46. The power dissipated in the circuit shown in the figure is 30 watts. The value of R is
(a) 20 Ω
(b) 15 Ω
(c) 10 Ω
(d) 30 Ω



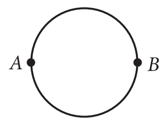
(Mains 2012)

47. If power dissipated in the 9 Ω resistor in the circuit shown is 36 watt, the potential difference across the 2 Ω resistor is
(a) 4 volt (b) 8 volt
(c) 10 volt (d) 2 volt



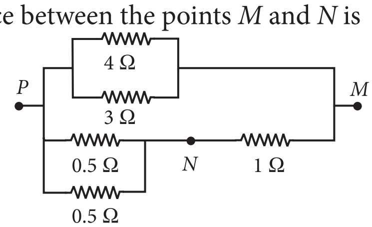
(2011)

48. A wire of resistance 12 ohms per meter is bent to form a complete circle of radius 10 cm. The resistance between its two diametrically opposite points, A and B as shown in the figure is



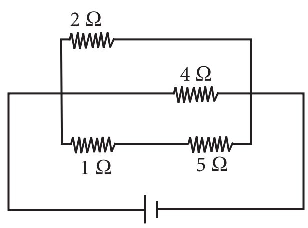
(a) 3 Ω (b) 6π Ω
(c) 6 Ω (d) 0.6π Ω *(2009)*

49. In the circuit shown, the current through the 4 Ω resistor is 1 amp when the points P and M are connected to a d.c. voltage source. The potential difference between the points M and N is

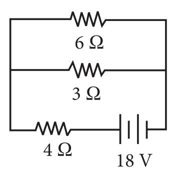


(a) 0.5 volt (b) 3.2 volt
(c) 1.5 volt (d) 1.0 volt *(2008)*

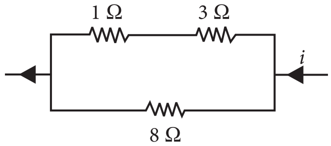
50. A current of 3 amp. flows through the 2 Ω resistor shown in the circuit. The power dissipated in the 5 Ω resistor is
(a) 1 watt
(b) 5 watt
(c) 4 watt (d) 2 watt *(2008)*



51. The total power dissipated in watt in the circuit shown here is
(a) 40
(b) 54
(c) 4
(d) 16. *(2007)*



52. Power dissipated across the 8 Ω resistor in the circuit shown here is 2 watt. The power dissipated in watt units across the 3 Ω resistor is



(a) 3.0 (b) 2.0 (c) 1.0 (d) 0.5 *(2006)*

53. When a wire of uniform cross-section a, length l and resistance R is bent into a complete circle, resistance between any two of diametrically opposite points will be
(a) $R/4$ (b) $4R$ (c) $R/8$ (d) $R/2$ *(2005)*

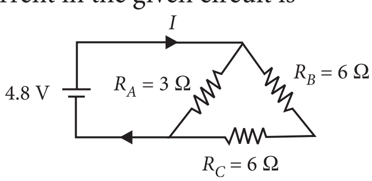
54. Resistance n, each of r ohm, when connected in parallel give an equivalent resistance of R ohm. If these resistances were connected in series, the combination would have a resistance in ohms, equal to
(a) n^2R (b) R/n^2 (c) R/n (d) nR *(2004)*

55. When three identical bulbs of 60 watt, 200 volt rating are connected in series to a 200 volt supply, the power drawn by them will be
(a) 60 watt (b) 180 watt
(c) 10 watt (d) 20 watt *(2004)*

56. Two 220 volt, 100 watt bulbs are connected first in series and then in parallel. Each time the combination is connected to a 220 volt a.c. supply line. The power drawn by the combination in each case respectively will be
(a) 50 watt, 100 watt (b) 100 watt, 50 watt
(c) 200 watt, 150 watt (d) 50 watt, 200 watt *(2003)*

57. An electric kettle has two heating coils. When one of the coils is connected to an a.c. source, the water in the kettle boils in 10 minutes. When the other coil is used the water boils in 40 minutes. If both the coils are connected in parallel, the time taken by the same quantity of water to boil will be
(a) 8 minutes (b) 4 minutes
(c) 25 minutes (d) 15 minutes *(2003)*

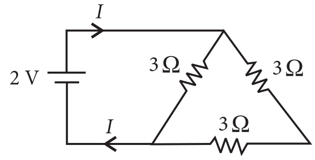
58. The current in the given circuit is



(a) 4.9 A (b) 6.8 A (c) 8.3 A (d) 2.0 A *(1999)*

59. Three equal resistors connected in series across a source of e.m.f. together dissipate 10 watt of power. What will be the power dissipated in watt if the same resistors are connected in parallel across the same source of e.m.f.?
(a) 30 (b) $\frac{10}{3}$ (c) 10 (d) 90 *(1998)*

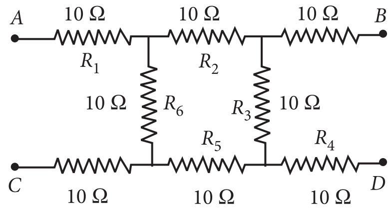
60. The current in the following circuit is



(a) 2/3 A (b) 1 A
(c) 1/8 A (d) 2/9 A *(1997)*

61. If two bulbs, whose resistances are in the ratio of 1 : 2 are connected in series, the power dissipated in them has the ratio of
(a) 2 : 1 (b) 1 : 4
(c) 1 : 1 (d) 1 : 2. *(1997)*

62. What will be the equivalent resistance between the two points A and D?

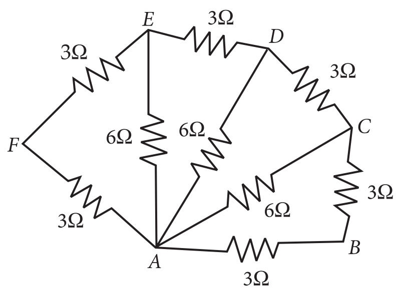


(a) 30 Ω (b) 40 Ω (c) 20 Ω (d) 10 Ω. *(1996)*

63. Two wires of the same metal have same length, but their cross-sections are in the ratio 3 : 1. They are joined in series. The resistance of thicker wire is 10 Ω. The total resistance of the combination will be
(a) 40 Ω (b) 100 Ω
(c) (5/2) Ω (d) (40/3) Ω. *(1995)*

64. A heating coil is labelled 100 W, 220 V. The coil is cut in half and the two pieces are joined in parallel to the same source. The energy now liberated per second is
(a) 200 W (b) 400 W
(c) 25 W (d) 50 W *(1995)*

65. Six resistors of 3 Ω each are connected along the sides of a hexagon and three resistors of 6 Ω each are connected along AC, AD and AE as shown in the figure. The equivalent resistance between A and B is equal to

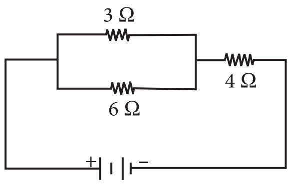


(a) 2 Ω (b) 6 Ω
(c) 3 Ω (d) 9 Ω *(1994)*

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

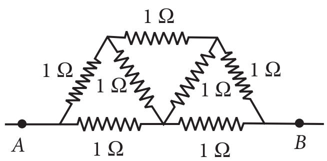
(a) 12 Ω (b) 2 Ω
(c) 6 Ω (d) 8/3 Ω *(1993)*

67. Current through 3 Ω resistor is 0.8 ampere, then potential drop through 4 Ω resistor is



(a) 9.6 V (b) 2.6 V
(c) 4.8 V (d) 1.2 V *(1993)*

68. In the network shown in figure each resistance is 1 Ω. The effective resistance between A and B is



(a) $\frac{4}{3}\Omega$ (b) $\frac{3}{2}\Omega$ (c) 7 Ω (d) $\frac{8}{7}\Omega$ *(1990)*

69. You are given several identical resistances each of value R = 10 Ω and each capable of carrying a maximum current of one ampere. It is required to make a suitable combination of these resistances of 5 Ω which can carry a current of 4 ampere. The minimum number of resistances of the type R that will be required for this job is

(a) 4 (b) 10 (c) 8 (d) 20 *(1990)*

70. 40 electric bulbs are connected in series across a 220 V supply. After one bulb is fused the remaining 39 are connected again in series across the same supply. The illumination will be

(a) more with 40 bulbs than with 39
(b) more with 39 bulbs than with 40
(c) equal in both the cases
(d) in the ratio $40^2 : 39^2$. *(1989)*

71. n equal resistors are first connected in series and then connected in parallel. What is the ratio of the maximum to the minimum resistance ?

(a) n (b) $1/n^2$ (c) n^2 (d) $1/n$ *(1989)*

3.11 Cells, EMF, Internal Resistance

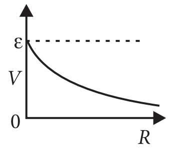
72. A set of n equal resistors, of value R each, are connected in series to a battery of emf E and internal resistance R. The current drawn is I. Now, the n resistors are connected in parallel to the same battery. Then the current drawn from battery becomes $10I$. The value of n is

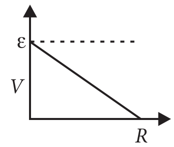
(a) 10 (b) 11
(c) 20 (d) 9 *(NEET 2018)*

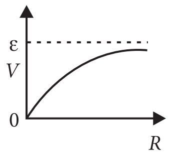
73. The internal resistance of a 2.1 V cell which gives a current of 0.2 A through a resistance of 10 Ω is

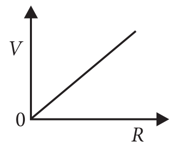
(a) 0.8 Ω (b) 1.0 Ω
(c) 0.2 Ω (d) 0.5 Ω *(NEET 2013)*

74. A cell having an emf ε and internal resistance r is connected across a variable external resistance R. As the resistance R is increased, the plot of potential difference V across R is given by

(a) 

(b) 

(c) 

(d) 

(Mains 2012)

75. A current of 2 A flows through a 2 Ω resistor when connected across a battery. The same battery supplies a current of 0.5 A when connected across a 9 Ω resistor. The internal resistance of the battery is

(a) 0.5 Ω (b) 1/3 Ω
(c) 1/4 Ω (d) 1 Ω *(2011)*

76. A student measures the terminal potential difference (V) of a cell (of emf ε and internal resistance r) as a function of the current (I) flowing through it. The slope, and intercept, of the graph between V and I, then, respectively, equal

(a) $-r$ and ε (b) r and $-$ε
(c) $-$ε and r (d) ε and $-r$ *(2009)*

77. For a cell terminal potential difference is 2.2V when circuit is open and reduces to 1.8 V when cell is connected to a resistance of R = 5 Ω. Determine internal resistance of cell (r).

(a) $\frac{10}{9}\Omega$ (b) $\frac{9}{10}\Omega$
(c) $\frac{11}{9}\Omega$ (d) $\frac{5}{9}\Omega$ *(2002)*

78. A car battery of emf 12 V and internal resistance 5×10^{-2} Ω, receives a current of 60 amp from external source, then terminal potential difference of battery is

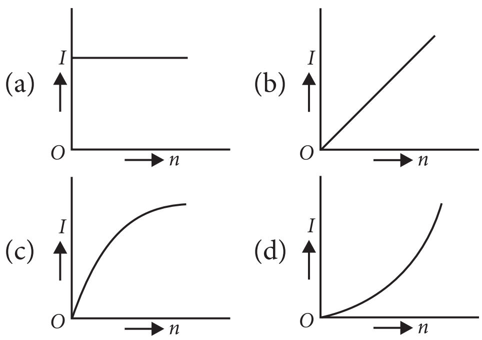
(a) 12 V (b) 9 V
(c) 15 V (d) 20 V *(2000)*

79. The internal resistance of a cell of e.m.f. 2 V is 0.1 Ω. It is connected to a resistance of 3.9 Ω. The voltage across the cell will be
(a) 1.95 V (b) 1.9 V
(c) 0.5 V (d) 2 V *(1999)*

80. A battery of e.m.f 10 V and internal resistance 0.5 Ω is connected across a variable resistance *R*. The value of *R* for which the power delivered in it is maximum is given by
(a) 0.5 Ω (b) 1.0 Ω
(c) 2.0 Ω (d) 0.25 Ω *(1992)*

3.12 Cells in Series and in Parallel

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

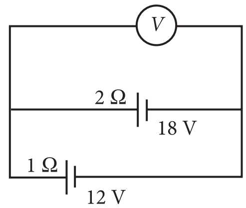


(NEET 2018)

82. Ten identical cells connected in series are needed to heat a wire of length one meter and radius '*r*' by 10°C in time '*t*'. How many cells will be required to heat the wire of length two meter of the same radius by the same temperature in time '*t*'?
(a) 20 (b) 30 (c) 40 (d) 10
(Karnataka NEET 2013)

83. Two cells, having the same e.m.f. are connected in series through an external resistance *R*. Cells have internal resistances r_1 and r_2 ($r_1 > r_2$) respectively. When the circuit is closed, the potential difference across the first cell is zero. The value of *R* is
(a) $r_1 + r_2$ (b) $r_1 - r_2$
(c) $\frac{r_1 + r_2}{2}$ (d) $\frac{r_1 - r_2}{2}$ *(2006)*

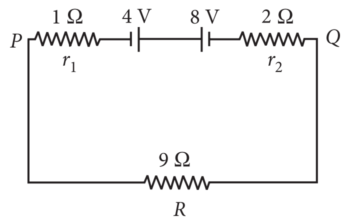
84. Two batteries, one of emf 18 volts and internal resistance 2 Ω and the other of emf 12 volts and internal resistance 1 Ω, are connected as shown. The voltmeter *V* will record a reading of



(a) 30 volt (b) 18 volt
(c) 15 volt (d) 14 volt *(2005)*

85. Two identical batteries each of e.m.f 2 V and internal resistance 1 Ω are available to produce heat in an external resistance by passing a current through it. The maximum power that can be developed across *R* using these batteries is
(a) 3.2 W (b) 2.0 W
(c) 1.28 W (d) $\frac{8}{9}$ W *(1990)*

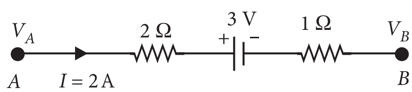
86. Two batteries of emf 4 V and 8 V with internal resistance 1 Ω and 2 Ω are connected in a circuit with resistance of 9 Ω as shown in figure. The current and potential difference between the points *P* and *Q* are



(a) $\frac{1}{3}$ A and 3 V (b) $\frac{1}{6}$ A and 4 V
(c) $\frac{1}{9}$ A and 9 V (d) $\frac{1}{12}$ A and 12 V *(1988)*

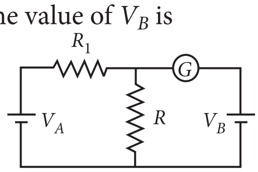
3.13 Kirchhoff's Rules

87. The potential difference ($V_A - V_B$) between the points *A* and *B* in the given figure is



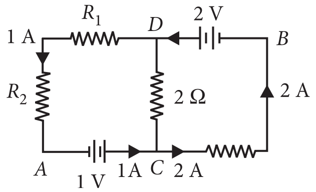
(a) –3 V (b) +3 V
(c) +6 V (d) +9 V *(NEET-II 2016)*

88. In the circuit shown the cells *A* and *B* have negligible resistances. For V_A = 12 V, R_1 = 500 Ω and *R* = 100 Ω the galvanometer (*G*) shows no deflection. The value of V_B is



(a) 4 V (b) 2 V
(c) 12 V (d) 6 V *(2012)*

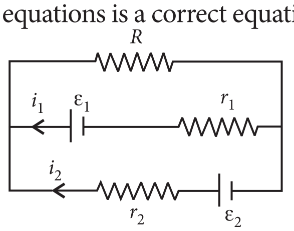
89. In the circuit shown in the figure, if the potential at point A is taken to be zero, the potential at point B is



(a) +1 V (b) −1 V (c) +2 V (d) −2 V *(Mains 2011)*

90. Consider the following two statements.
(A) Kirchhoff's junction law follows from the conservation of charge.
(B) Kirchhoff's loop law follows from the conservation of energy.
Which of the following is correct?
(a) Both (A) and (B) are wrong.
(b) (A) is correct and (B) is wrong.
(c) (A) is wrong and (B) is correct.
(d) Both (A) and (B) are correct. *(2010)*

91. See the electrical circuit shown in this figure. Which of the following equations is a correct equation for it?



(a) $\varepsilon_2 - i_2 r_2 - \varepsilon_1 - i_1 r_1 = 0$
(b) $-\varepsilon_2 - (i_1 + i_2)R + i_2 r_2 = 0$
(c) $\varepsilon_1 - (i_1 + i_2)R + i_1 r_1 = 0$
(d) $\varepsilon_1 - (i_1 + i_2)R - i_1 r_1 = 0$ *(2009)*

92. Kirchhoff's first and second laws of electrical circuits are consequences of
(a) conservation of energy and electric charge respectively
(b) conservation of energy
(c) conservation of electric charge and energy respectively
(d) conservation of electric charge. *(2006)*

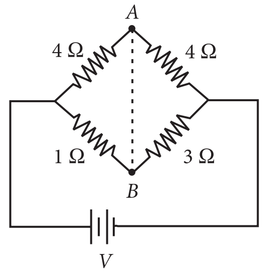
93. Kirchhoff's first law, *i.e.* $\Sigma\, i = 0$ at a junction, deals with the conservation of
(a) momentum (b) angular momentum
(c) charge (d) energy *(1997, 1992)*

3.14 Wheatstone Bridge

94. The resistances of the four arms P, Q, R and S in a Wheatstone's bridge are 10 ohm, 30 ohm, 30 ohm and 90 ohm, respectively. The e.m.f. and internal resistance of the cell are 7 volt and 5 ohm respectively. If the galvanometer resistance is 50 ohm, the current drawn from the cell will be
(a) 0.1 A (b) 2.0 A
(c) 1.0 A (d) 0.2 A *(NEET 2013)*

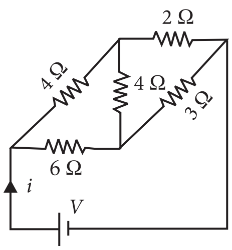
95. Three resistances P, Q, R each of 2 Ω and an unknown resistance S form the four arms of a Wheatstone bridge circuit. When a resistance of 6 Ω is connected in parallel to S the bridge gets balanced. What is the value of S ?
(a) 3 Ω (b) 6 Ω (c) 1 Ω (d) 2 Ω *(2007)*

96. In the circuit shown, if a conducting wire is connected between points A and B, the current in this wire will



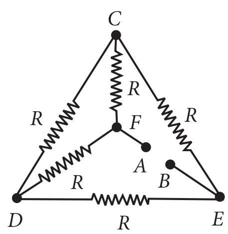
(a) flow from B to A
(b) flow from A to B
(c) flow in the direction which will be decided by the value of V
(d) be zero. *(2006)*

97. For the network shown in the figure the value of the current i is



(a) $\frac{9V}{35}$ (b) $\frac{18V}{5}$ (c) $\frac{5V}{9}$ (d) $\frac{5V}{18}$ *(2005)*

98. Five equal resistances each of resistance R are connected as shown in the figure. A battery of V volts is connected between A and B. The current flowing in $AFCEB$ will be

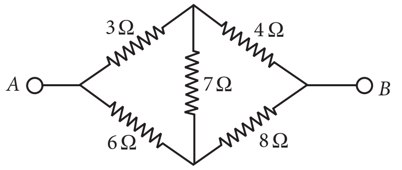


(a) $\frac{3V}{R}$ (b) $\frac{V}{R}$
(c) $\frac{V}{2R}$ (d) $\frac{2V}{R}$ *(2004)*

99. In a Wheatstone's bridge all the four arms have equal resistance R. If the resistance of the galvanometer arm is also R, the equivalent resistance of the combination as seen by the battery is
(a) $R/4$ (b) $R/2$ (c) R (d) $2R$ *(2003)*

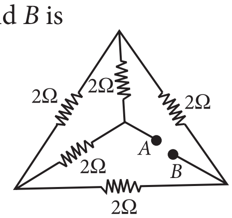
100. The resistance of each arm of the Wheatstone's bridge is 10 ohm. A resistance of 10 ohm is connected in series with a galvanometer then the equivalent resistance across the battery will be
(a) 10 ohm (b) 15 ohm
(c) 20 ohm (d) 40 ohm *(2001)*

101. The net resistance of the circuit between A and B is



(a) $\frac{8}{3}\Omega$ (b) $\frac{14}{3}\Omega$
(c) $\frac{16}{3}\Omega$ (d) $\frac{22}{3}\Omega$ *(2000)*

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

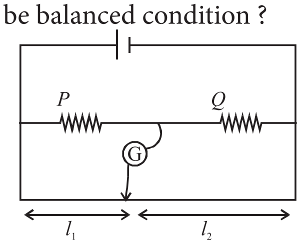


(a) 3 Ω (b) 4 Ω (c) 1 Ω (d) 2 Ω *(1995)*

3.15 Metre Bridge

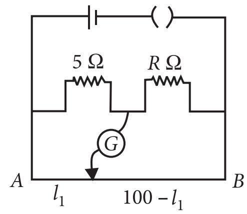
103. A resistance wire connected in the left gap of a metre bridge balances a 10 Ω resistance in the right gap at a point which divides the bridge wire in the ratio 3 : 2. If the length of the resistance wire is 1.5 m, then the length of 1 Ω of the resistance wire is
(a) 1.0×10^{-2} m (b) 1.0×10^{-1} m
(c) 1.5×10^{-1} m (d) 1.5×10^{-2} m
(NEET 2020)

104. The metre bridge shown is in balance position with $\frac{P}{Q} = \frac{l_1}{l_2}$. If we now interchange the positions of galvanometer and cell, will the bridge work ? If yes, what will be balanced condition ?



(a) yes, $\frac{P}{Q} = \frac{l_2 - l_1}{l_2 + l_1}$ (b) no, no null point
(c) yes, $\frac{P}{Q} = \frac{l_2}{l_1}$ (d) yes, $\frac{P}{Q} = \frac{l_1}{l_2}$
(Odisha NEET 2019)

105. The resistances in the two arms of the meter bridge are 5 Ω and R Ω respectively. When the resistance R is shunted with an equal resistance, the new balance point is at 1.6 l_1. The resistance R is



(a) 10 Ω (b) 15 Ω
(c) 20 Ω (d) 25 Ω *(2014)*

106. In a metre bridge, the balancing length from the left end (standard resistance of one ohm is in the right gap) is found to be 20 cm. The value of the unknown resistance is
(a) 0.8 Ω (b) 0.5 Ω
(c) 0.4 Ω (d) 0.25 Ω *(1999)*

3.16 Potentiometer

107. A potentiometer is an accurate and versatile device to make electrical measurements of EMF because the method involves
(a) potential gradients
(b) a condition of no current flow through the galvanometer
(c) a combination of cells, galvanometer and resistances
(d) cells. *(NEET 2017)*

108. A potentiometer wire is 100 cm long and a constant potential difference is maintained across it. Two cells are connected in series first to support one another and then in opposite direction. The balance points ar0e obtained at 50 cm and 10 cm from the positive end of the wire in the two cases. The ratio of emf's is
(a) 3 : 4 (b) 3 : 2
(c) 5 : 1 (d) 5 : 4 *(NEET-I 2016)*

109. A potentiometer wire of length L and a resistance r are connected in series with a battery of e.m.f. E_0 and a resistance r_1. An unknown e.m.f. E is balanced at a length l of the potentiometer wire. The e.m.f. E will be given by

(a) $\dfrac{E_0 l}{L}$ (b) $\dfrac{LE_0 r}{(r+r_1)l}$

(c) $\dfrac{LE_0 r}{lr_1}$ (d) $\dfrac{E_0 r}{(r+r_1)}\cdot\dfrac{l}{L}$ *(2015)*

110. A potentiometer wire has length 4 m and resistance 8 Ω. The resistance that must be connected in series with the wire and an accumulator of e.m.f. 2 V, so as to get a potential gradient 1 mV per cm on the wire is

(a) 44 Ω (b) 48 Ω

(c) 32 Ω (d) 40 Ω *(2015 Cancelled)*

111. A potentiometer circuit has been set up for finding the internal resistance of a given cell. The main battery, used across the potentiometer wire, has an emf of 2.0 V and a negligible internal resistance. The potentiometer wire itself is 4 m long. When the resistance *R*, connected across the given cell, has values of

(i) infinity

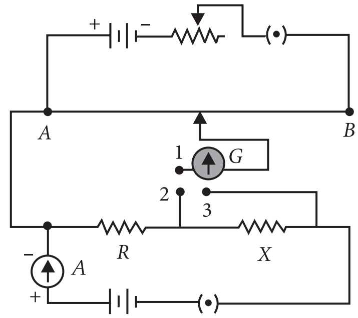
(ii) 9.5 Ω

the balancing lengths on the potentiometer wire are found to be 3 m and 2.85 m, respectively. The value of internal resistance of the cell is

(a) 0.25 Ω (b) 0.95 Ω

(c) 0.5 Ω (d) 0.75 Ω *(2014)*

112. A potentiometer circuit is set up as shown. The potential gradient, across the potentiometer wire, is *k* volt/cm and the ammeter, present in the circuit, reads 1.0 A when two way key is switched off. The balance points, when the key between the terminals (i) 1 and 2 (ii) 1 and 3, is plugged in, are found to be at lengths l_1 cm and l_2 cm respectively. The magnitudes, of the resistors *R* and *X*, in ohms, are then, equal, respectively, to



(a) $k(l_2 - l_1)$ and kl_2 (b) kl_1 and $k(l_2 - l_1)$

(c) $k(l_2 - l_1)$ and kl_1 (d) kl_1 and kl_2 *(2010)*

113. A cell can be balanced against 110 cm and 100 cm of potentiometer wire, respectively with and without being short circuited through a resistance of 10 Ω. Its internal resistance is

(a) 2.0 ohm (b) zero

(c) 1.0 ohm (d) 0.5 ohm *(2008)*

114. If specific resistance of a potentiometer wire is 10^{-7} Ω m and current flow through it is 0.1 amp., cross-sectional area of wire is 10^{-6} m^2 then potential gradient will be

(a) 10^{-2} volt/m (b) 10^{-4} volt/m

(c) 10^{-6} volt/m (d) 10^{-8} volt/m. *(2001)*

115. The potentiometer is best for measuring voltage, as

(a) it has a sensitive galvanometer and gives null deflection

(b) it has wire of high resistance

(c) it measures p.d. like in closed circuit

(d) it measures p.d. like in open circuit. *(2000)*

116. A potentiometer consists of a wire of length 4 m and resistance 10 Ω. It is connected to a cell of e.m.f. 2 V. The potential difference per unit length of the wire will be

(a) 5 V/m (b) 2 V/m

(c) 0.5 V/m (d) 10 V/m *(1999)*

ANSWER KEY

1. (a)	**2.** (b)	**3.** (b)	**4.** (d)	**5.** (b)	**6.** (c)	**7.** (a)	**8.** (b)	**9.** (d)	**10.** (b)
11. (c)	**12.** (a)	**13.** (a)	**14.** (a)	**15.** (d)	**16.** (b)	**17.** (c)	**18.** (c)	**19.** (d)	**20.** (a)
21. (a)	**22.** (a)	**23.** (c)	**24.** (b)	**25.** (c)	**26.** (c)	**27.** (a)	**28.** (c)	**29.** (b)	**30.** (b)
31. (a)	**32.** (c)	**33.** (c)	**34.** (d)	**35.** (d)	**36.** (b)	**37.** (d)	**38.** (c)	**39.** (c)	**40.** (c)
41. (c)	**42.** (c)	**43.** (d)	**44.** (b)	**45.** (d)	**46.** (c)	**47.** (c)	**48.** (d)	**49.** (b)	**50.** (b)
51. (b)	**52.** (a)	**53.** (a)	**54.** (a)	**55.** (d)	**56.** (d)	**57.** (a)	**58.** (d)	**59.** (d)	**60.** (b)
61. (d)	**62.** (a)	**63.** (a)	**64.** (b)	**65.** (a)	**66.** (d)	**67.** (c)	**68.** (d)	**69.** (c)	**70.** (b)
71. (c)	**72.** (a)	**73.** (d)	**74.** (c)	**75.** (b)	**76.** (a)	**77.** (a)	**78.** (c)	**79.** (a)	**80.** (a)
81. (a)	**82.** (a)	**83.** (b)	**84.** (d)	**85.** (b)	**86.** (a)	**87.** (d)	**88.** (b)	**89.** (a)	**90.** (d)
91. (d)	**92.** (c)	**93.** (c)	**94.** (d)	**95.** (a)	**96.** (a)	**97.** (d)	**98.** (c)	**99.** (c)	**100.** (a)
101. (b)	**102.** (d)	**103.** (b)	**104.** (d)	**105.** (b)	**106.** (d)	**107.** (b)	**108.** (b)	**109.** (d)	**110.** (c)
111. (c)	**112.** (b)	**113.** (c)	**114.** (a)	**115.** (d)	**116.** (c)				

Hints & Explanations

1. (a) : Flow of electrons, $\frac{n}{t} = 10^7$/second

Therefore, current$(I) = \frac{q}{t} = \frac{ne}{t} = \frac{n}{t} \times e$

$= 10^7 \times (1.6 \times 10^{-19}) = 1.6 \times 10^{-12}$ A

2. (b) : The resistance of a wire of length l and area A and resistivity ρ is given as

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

Given, $l' = nl$

As the volume of the wire remains constant

$$\therefore \quad A'l' = Al \quad \text{or} \quad A' = \frac{Al}{l'} = \frac{Al}{nl} \quad \text{or} \quad A' = \frac{A}{n}$$

$$\therefore \quad R' = \frac{\rho l'}{A'} \quad \text{or} \quad R' = \frac{\rho nl}{\frac{A}{n}} = \frac{n^2 \rho l}{A} = n^2 R$$

3. (b) : Resistance of a wire, $R = \rho\frac{l}{A} = 4\ \Omega$ ...(i)

When wire is stretched twice, its new length be l'. Then

$l' = 2l$

On stretching volume of the wire remains constant.

$\therefore$ $lA = l'A'$ where A' is the new cross-sectional area

$$\text{or} \quad A' = \frac{l}{l'}A = \frac{l}{2l}A = \frac{A}{2}$$

$\therefore$ Resistance of the stretched wire is

$$R' = \rho\frac{l'}{A'} = \rho\frac{2l}{(A/2)} = 4\rho\frac{l}{A}$$

$= 4(4\ \Omega) = 16\ \Omega$ (Using (i))

4. (d) : $\frac{\Delta l}{l} = 0.1 \quad \therefore \quad l = 1.1$

But the area also decreases by 0.1.

Mass = $\rho lA = V\rho$, ln l + ln A = ln mass.

$$\therefore \frac{\Delta l}{l} + \frac{\Delta A}{A} = 0 \Rightarrow \frac{\Delta l}{l} = \frac{-\Delta A}{A}$$

Length increases by 0.1, resistance increases, area decreases by 0.1, then also resistance will increase. Total increase in resistance is approximately 1.2 times, due to increase in length and decrease in area. But specific resistance does not change.

5. (b) : Resistance of wire $= \rho\frac{l}{A}$

$$R \propto \frac{l}{A} = \frac{l}{\pi r^2}$$

When length and radius are both doubled

$$R_1 \propto \frac{2l}{\pi(2r)^2} \Rightarrow R_1 \propto \frac{1}{2}R$$

The specific resistance of wire is independent of geometry of the wire, it only depends on the material of the wire.

6. (c) : According to given parameters in question

$$R = \rho\frac{l}{A} \Rightarrow 100\ \Omega = \rho\frac{3}{A} \Rightarrow \frac{\rho}{A} = \frac{100}{3}$$

Thus total resistance of 50 cm wire is

$$R_1 = \frac{\rho}{A}l = \frac{100}{3} \times 0.5 = \frac{50}{3}\ \Omega.$$

The total current in the wire is $I = \frac{6}{100}$ A.

Therefore potential difference across the two points on the wire separated by a distance of 50 m is

$$V = IR_1 = \frac{50}{3} \times \frac{6}{100} = 1\text{ V}$$

7. (a) : Three wires of lengths and cross-sectional areas = (l, A), $(2l, A/2)$ and $(l/2, 2A)$.

Resistance of a wire $R \propto \frac{l}{A}$

For Ist wire, $R_1 \propto l/A = R$

For IInd wire, $R_2 \propto \frac{2l}{A/2} = 4R$

For IIIrd wire, $R_3 \propto \frac{l/2}{2A} = \frac{R}{4}$

Therefore resistance of the wire will be minimum for IIIrd wire.

8. (b) : Length (l) = 50 cm = 0.5 m;

Area (A) = 1 mm^2 = 1×10^{-6} m^2;

Current (I) = 4A and voltage (V) = 2 volts.

$$\text{Resistance}(R) = \frac{V}{I} = \frac{2}{4} = 0.5\ \Omega$$

$$\text{Resistivity}(\rho) = R \times \frac{A}{l} = 0.5 \times \frac{1 \times 10^{-6}}{0.5} = 1 \times 10^{-6}\ \Omega\text{ m}$$

9. (d) : $m = l \times$ area $\times$ density

$$\text{Area} \propto \frac{m}{l}$$

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

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

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

10. (b) : Here, $v_d = 7.5 \times 10^{-4}$ m/s, $E = 3 \times 10^{-10}$ V/m

$$\text{Mobility, } \mu = \frac{v_d}{E} = \frac{7.5 \times 10^{-4}}{3 \times 10^{-10}}$$

$\mu = 2.5 \times 10^6$

11. (c) : Energy = 2 eV = $eE\lambda$

$$\therefore \quad E=\frac{2}{\lambda}=\frac{2}{4\times10^{-8}}=5\times10^{7}\ \text{V/m}$$

12. (a) **13. (a)**

14. (a) : For the negative resistance, when we increase the voltage, the current will decrease. Therefore from the graph, we find that the current in *CD* is decreased when voltage is increased.

15. (d) : The colour code of the given resistor is yellow, violet, brown and gold.

According to the colour code digits are

Yellow - 4
Violet - 7
Brown - 1

and Gold = 5%

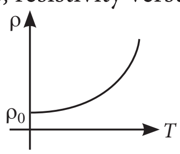
$\therefore \quad R = 47 \times 10^1 \pm 5\% = 470\ \Omega \pm 5\%$

16. (b) : (47 ± 4.7) kΩ $= 47 \times 10^3 \pm 10\%\ \Omega$

$\therefore$ Yellow – Violet – Orange – Silver

17. (c)

18. (c) : For metals, resistivity versus time graph is



19. (d)

20. (a) : Specific resistance is a property of a material and it increases with the increase of temperature, but not vary with the dimensions (length, cross-section) of the conductor.

21. (a) : For metal specific resistance decreases with decrease in temperature whereas for semiconductor specific resistance increases with decrease in temperature.

22. (a) : Fuse is an electrical safety device that operates to provide overcurrent protection to an electrical circuit.

23. (c) : Given, $Q = at - bt^2$

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

At $t = 0, Q = 0 \Rightarrow I = 0$

Also, $I = 0$ at $t = a/2b$

$\therefore$ Total heat produced in resistance R,

$$H=\int_0^{a/2b} I^2R\,dt = R\int_0^{a/2b}(a-2bt)^2\,dt$$

$$=R\int_0^{a/2b}(a^2+4b^2t^2-4abt)\,dt$$

$$=R\left[a^2t+4b^2\frac{t^3}{3}-4ab\frac{t^2}{2}\right]_0^{a/2b}$$

$$=R\left[a^2\times\frac{a}{2b}+\frac{4b^2}{3}\times\frac{a^3}{8b^3}-\frac{4ab}{2}\times\frac{a^2}{4b^2}\right]$$

$$=\frac{a^3R}{b}\left[\frac{1}{2}+\frac{1}{6}-\frac{1}{2}\right]=\frac{a^3R}{6b}$$

24. (b) : Here,

Distance between two cities = 150 km

Resistance of the wire,

$R = (0.5\ \Omega\ \text{km}^{-1})(150\ \text{km}) = 75\ \Omega$

Voltage drop across the wire,

$V = (8\ \text{V km}^{-1})(150\ \text{km}) = 1200$ V

Power loss in the wire is

$$P=\frac{V^2}{R}=\frac{(1200\ \text{V})^2}{75\ \Omega}=19200\ \text{W}=19.2\ \text{kW}$$

25. (c) : Power, $P=\dfrac{V^2}{R}$

As the resistance of the bulb is constant

$$\therefore \quad \frac{\Delta P}{P}=\frac{2\Delta V}{V}$$

$$\%\ \text{decrease in power}=\frac{\Delta P}{P}\times100=\frac{2\Delta V}{V}\times100$$

$= 2 \times 2.5\% = 5\%$

26. (c) : Power = 220 V × 4 A = 880 watts

Heat needed to raise the temperature of 1 kg water through 80°C

$= ms.\Delta T = 1 \times 4200 \times 80\ \text{J} = 336 \times 10^3$ J

$$\therefore \quad \text{Time taken}=\frac{336\times10^3}{880}$$

= 382 s = 6.3 min

27. (a) : $P = i^2R$ or $1 = 25 \times R$

$$R=\frac{1}{25}=0.04\ \Omega$$

28. (c) : In India, $P_I=\dfrac{(220)^2}{R}$; In USA, $P_U=\dfrac{(110)^2}{R_U}$

$$\text{As } P_I=P_U \Rightarrow \frac{(220)^2}{R}=\frac{(110)^2}{R_U} \Rightarrow R_U=\frac{R}{4}$$

29. (b) : Fuse wire should have high resistance and low melting point.

30. (b) : $P=\dfrac{V^2}{R}$ or, $R\propto\dfrac{1}{P}$

$\therefore \quad R_{40} > R_{100}$

31. (a) : $H = I^2Rt = ms\Delta T$

$$\frac{I_1^2}{I_2^2}=\frac{\Delta T_1}{\Delta T_2} \quad \text{or,} \quad \Delta T_2=\frac{\Delta T_1 I_2^2}{I_1^2}$$

$$\Delta T_2 = 5\times\frac{(2I_1)^2}{I_1^2}=20°\text{C}$$

32. (c) : Power = 100 W; Voltage of bulb = 200 V and supply voltage (V_s) = 160 V
Therefore resistance of bulb (R)

$$= \frac{V^2}{P} = \frac{(200)^2}{100} = 400\ \Omega$$

and power consumption (P)

$$= \frac{V_s^2}{R} = \frac{(160)^2}{400} = 64\ \text{W}$$

33. (c) : 1 kWh = 1000 Wh

$$= (1000\ \text{W}) \times (3600\ \text{s}) = 36 \times 10^5\ \text{J}$$

34. (d) : Capacitance (C) = 4 μF = 4×10^{-6} F; Voltage (V) = 400 volts and resistance (R) = 2 kΩ = $2 \times 10^3\ \Omega$

Heat produced = Electrical energy stored $= \frac{1}{2}CV^2$

$$= \frac{1}{2} \times (4 \times 10^{-6}) \times (400)^2 = 0.32\ \text{J}.$$

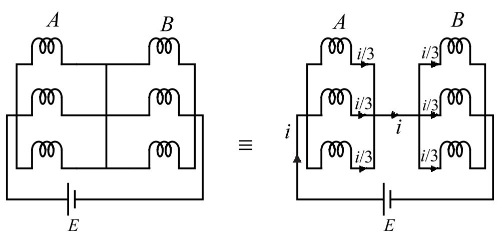
35. (d) : Power (P) = 60 W and voltage (V) = 220 V
Resistance of the filament,

$$R = \frac{V^2}{P} = \frac{(220)^2}{60} = 807\ \Omega$$

36. (b) : $H = I^2Rt$ or $R = \frac{H}{(I^2 t)} = \frac{80}{(2^2 \times 10)} = 2\ \Omega$

37. (d)

38. (c) :



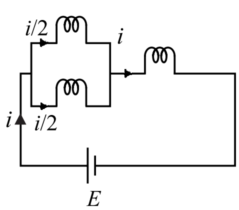
Let R be the resistance of the each bulb.

Case (i)

Net resistance of the circuit, $R_1 = \frac{R}{3} + \frac{R}{3} = \frac{2R}{3}$

Power consumption by the bulbs = Power supply by the sources

$$\Rightarrow P_1 = \frac{E^2}{(2R/3)} = \frac{3E^2}{2R}$$



Case (ii)

Net resistance of the circuit,

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

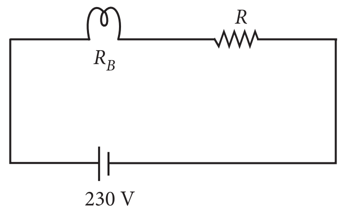
Power consumption by the bulbs,

$$P_2 = \frac{E^2}{(3R/2)} = \frac{2}{3}\left(\frac{E^2}{R}\right); \frac{P_1}{P_2} = \frac{3}{2} \times \frac{3}{2} = \frac{9}{4}$$

39. (c) : Resistance of bulb,

$$R_B = \frac{V^2}{P} = \frac{(100)^2}{500} = 20\ \Omega$$

Power of the bulb in the circuit,



$$P = VI;\ I = \frac{P}{V_B};\ I = \frac{500}{100} = 5\ \text{A}$$

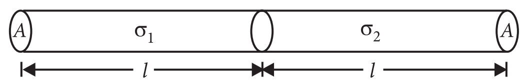
$$V_R = IR \Rightarrow (230 - 100) = 5 \times R$$

$\therefore\ R = 26\ \Omega$

40. (c) : As both metal wires are of identical dimensions, so their length and area of cross-section will be same. Let them be l and A respectively. Then the resistance of the first wire is

$$R_1 = \frac{l}{\sigma_1 A} \qquad \text{... (i)}$$

and that of the second wire is $R_2 = \frac{l}{\sigma_2 A}$ ... (ii)



As they are connected in series, so their effective resistance is

$$R_s = R_1 + R_2 = \frac{l}{\sigma_1 A} + \frac{l}{\sigma_2 A} \qquad \text{(using (i) and (ii))}$$

$$= \frac{l}{A}\left(\frac{1}{\sigma_1} + \frac{1}{\sigma_2}\right) \qquad \text{... (iii)}$$

If σ_{eff} is the effective conductivity of the combination, then

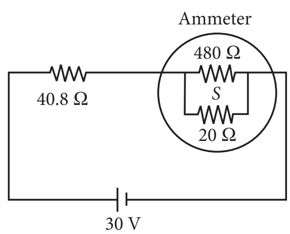
$$R_s = \frac{2l}{\sigma_{eff} A} \qquad \text{... (iv)}$$

Equating eqns. (iii) and (iv), we get

$$\frac{2l}{\sigma_{eff} A} = \frac{l}{A}\left(\frac{1}{\sigma_1} + \frac{1}{\sigma_2}\right)$$

$$\frac{2}{\sigma_{eff}} = \frac{\sigma_2 + \sigma_1}{\sigma_1 \sigma_2} \text{ or } \sigma_{eff} = \frac{2\sigma_1\sigma_2}{\sigma_1 + \sigma_2}$$

41. (c) : The circuit is shown in the figure.



Resistance of the ammeter is

$$R_A = \frac{(480\ \Omega)(20\ \Omega)}{(480\ \Omega + 20\ \Omega)} = 19.2\ \Omega$$

(As 480 Ω and 20 Ω are in parallel)

As ammeter is in series with 40.8 Ω,

$\therefore$ Total resistance of the circuit is

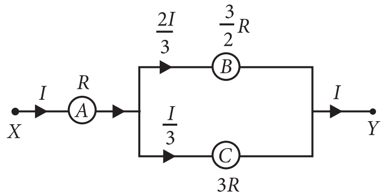
$$R = 40.8\ \Omega + R_A = 40.8\ \Omega + 19.2\ \Omega = 60\ \Omega$$

By Ohm's law, current in the circuit is

$$I = \frac{V}{R} = \frac{30\ \text{V}}{60\ \Omega} = \frac{1}{2}\ \text{A} = 0.5\ \text{A}$$

Thus the reading in the ammeter will be 0.5 A.

42. (c) : The current flowing in the different branches of circuit is indicated in the figure.



$$V_A = IR,\ V_B = \frac{2I}{3} \times \frac{3}{2} R = IR,\ V_C = \frac{I}{3} \times 3R = IR$$

Thus, $V_A = V_B = V_C$

43. (d) : Here, length of each rod, $l = 1$ m

Area of cross-section of each rod,

$A = 0.01\ \text{cm}^2 = 0.01 \times 10^{-4}\ \text{m}^2$

Resistivity of copper rod,

$\rho_{cu} = 1.7 \times 10^{-6}\ \Omega\ \text{cm} = 1.7 \times 10^{-6} \times 10^{-2}\ \Omega\ \text{m}$

$= 1.7 \times 10^{-8}\ \Omega\ \text{m}$

Resistivity of iron rod,

$\rho_{Fe} = 10^{-5}\ \Omega\ \text{cm} = 10^{-5} \times 10^{-2}\ \Omega\ \text{m} = 10^{-7}\ \Omega\ \text{m}$

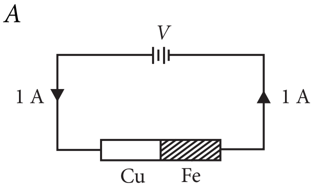
∴ Resistance of copper rod, $R_{Cu} = \rho_{Cu} \frac{l}{A}$

and resistance of iron rod, $R_{Fe} = \rho_{Fe} \frac{l}{A}$

As copper and iron rods are connected in series, therefore equivalent resistance is

$$R = R_{Cu} + R_{Fe} = \rho_{Cu} \frac{l}{A} + \rho_{Fe} \frac{l}{A}$$

$$= (\rho_{Cu} + \rho_{Fe}) \frac{l}{A}$$



Voltage required to produce 1 A current in the rods is

$V = IR = (1)(R_{Cu} + R_{Fe})$

$$= (\rho_{Cu} + \rho_{Fe}) \left(\frac{l}{A}\right)$$

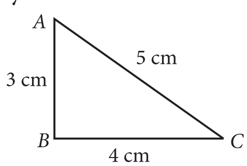
$$= (1.7 \times 10^{-8} + 10^{-7}) \left(\frac{1}{0.01 \times 10^{-4}}\right) \text{V}$$

$= 10^{-7}\ (0.17 + 1)(10^6)\ \text{V} = 1.17 \times 10^{-1}\ \text{V}$

$= 0.117$ V

44. (b) : Let ρ and A be resistivity and area of cross-section of the wire respectively.

The wire is bent in the form of right triangle as shown in figure.



Resistance of side AB is $R_1 = \frac{3\rho}{A}$

Resistance of side BC is $R_2 = \frac{4\rho}{A}$

Resistance of side AC is $R_3 = \frac{5\rho}{A}$

∴ The resistance between the ends A and B is

$$R_{AB} = \frac{R_1(R_2 + R_3)}{R_1 + R_2 + R_3} = \frac{\frac{3\rho}{A}\left(\frac{4\rho}{A} + \frac{5\rho}{A}\right)}{\frac{3\rho}{A} + \left(\frac{4\rho}{A} + \frac{5\rho}{A}\right)} = \frac{27}{12} \frac{\rho}{A}$$

The resistance between the ends B and C is

$$R_{BC} = \frac{R_2(R_1 + R_3)}{R_2 + R_1 + R_3} = \frac{\frac{4\rho}{A}\left(\frac{3\rho}{A} + \frac{5\rho}{A}\right)}{\frac{4\rho}{A} + \frac{3\rho}{A} + \frac{5\rho}{A}} = \frac{32}{12} \frac{\rho}{A}$$

The resistance between the ends A and C is

$$R_{AC} = \frac{R_3(R_1 + R_2)}{R_3 + R_1 + R_2} = \frac{\frac{5\rho}{A}\left(\frac{3\rho}{A} + \frac{4\rho}{A}\right)}{\frac{5\rho}{A} + \frac{3\rho}{A} + \frac{4\rho}{A}} = \frac{35}{12} \frac{\rho}{A}$$

$$\therefore\ R_{AB} : R_{BC} : R_{AC} = \frac{27}{12} : \frac{32}{12} : \frac{35}{12} = 27 : 32 : 35$$

45. (d) : Let x be resistance per unit length of the wire.

Then, the resistance of the upper portion is, $R_1 = xl_1$

the resistance of the lower portion is, $R_2 = xl_2$

Equivalent resistance between A and B is

$$R = \frac{R_1 R_2}{R_1 + R_2} = \frac{(xl_1)(xl_2)}{xl_1 + xl_2}$$

$$\frac{8}{3} = \frac{xl_1 l_2}{l_1 + l_2} \text{ or } \frac{8}{3} = \frac{xl_1 l_2}{l_2\left(\frac{l_1}{l_2} + 1\right)} \text{ or } \frac{8}{3} = \frac{xl_1}{\left(\frac{l_1}{l_2} + 1\right)} \quad \text{...(i)}$$

Also $R_0 = xl_1 + xl_2$

$12 = x(l_1 + l_2)$

$$12 = xl_2\left(\frac{l_1}{l_2} + 1\right) \quad \text{...(ii)}$$

Divide (i) by (ii), we get

$$\frac{\frac{8}{3}}{12} = \frac{\frac{xl_1}{\left(\frac{l_1}{l_2} + 1\right)}}{xl_2\left(\frac{l_1}{l_2} + 1\right)} \text{ or } \frac{8}{36} = \frac{l_1}{l_2\left(\frac{l_1}{l_2} + 1\right)^2}$$

$$\left(\frac{l_1}{l_2} + 1\right)^2 \frac{8}{36} = \frac{l_1}{l_2} \text{ or } \left(\frac{l_1}{l_2} + 1\right)^2 \frac{2}{9} = \frac{l_1}{l_2}$$

Let $y = \frac{l_1}{l_2}$

∴ $2(y + 1)^2 = 9y$ or $2y^2 + 2 + 4y = 9y$

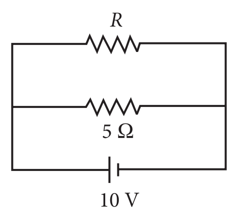
or $2y^2 - 5y + 2 = 0$

Solving this quadratic equation, we get

$$y = \frac{1}{2} \text{ or } 2\ \therefore\ \frac{l_1}{l_2} = \frac{1}{2}$$

46. (c) : The equivalent resistance of the given circuit is

$$R_{eq} = \frac{5R}{5 + R}$$



Power dissipated in the given circuit is

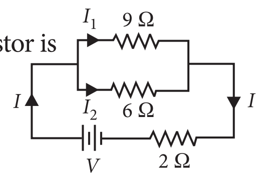
$$P = \frac{V^2}{R_{eq}} \text{ or } 30 = \frac{(10)^2}{\left(\frac{5R}{5+R}\right)}$$

$150R = 100(5 + R)$ or $150R = 500 + 100R$ or $50R = 500$

$$R = \frac{500}{50} = 10\ \Omega$$

47. (c) : As $P = I^2R$

Current flows through the 9 Ω resistor is



$$I_1^2 = \frac{36}{9} = 4$$

$I_1 = 2$ A

As the resistors 9 Ω and 6 Ω are connected in parallel, therefore potential difference across them is same.

$$\therefore\ 9I_1 = 6I_2;\ I_2 = \frac{9\times 2}{6} = 3\text{ A}$$

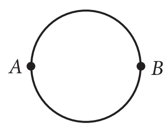
Current drawn from the battery is

$I = I_1 + I_2 = (2 + 3)$ A = 5 A

The potential difference across the 2 Ω resistor

= (5 A)(2 Ω) = 10 V

48. (d) : Wire of length 2π × 0.1 m of resistance 12 Ω/m is bent to form a circle.



Resistance of each part

= 12 × π × 0.1 = 1.2π Ω

∴ Resistance between A and B = 0.6π Ω

49. (b) : As the P.D. across 4 Ω and 3 Ω (in parallel), are the same,

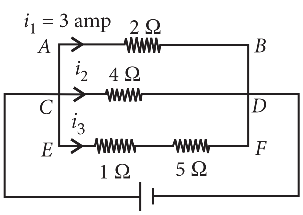
$$V = 4\times 1\text{ A} = 4\text{ V}$$

∴ P.D. across points P and M = 4 V

$$\text{Current in } MNP = \frac{4}{1.25} = \frac{4\times 4}{5} = \frac{16}{5}\text{ A}$$

$$\therefore\ \text{P.D. across } 1\ \Omega = \frac{16}{5}\text{ A}\times 1\ \Omega = \frac{16}{5}\text{ volt} = 3.2\text{ volt}$$

50. (b) :



2 Ω, 4 Ω and (1 Ω + 5 Ω) are in parallel. So potential difference is the same.

$V = 2\ \Omega \cdot i_1 = 4\ \Omega \cdot i_2 = 6\ \Omega \cdot i_3$

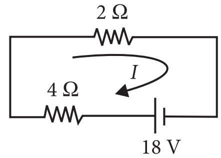
$2 \cdot 3 = 6\ \Omega \,.\, i_3 \Rightarrow i_3 = 1$ amp.

∴ Power dissipated in 5 Ω resistance

$$= i_3^2 R = 1^2 \times 5 = 5\text{ W}$$

51. (b) : In the given circuit 6 Ω and 3 Ω are in parallel, and hence its equivalent resistance is given by

$$\frac{1}{R_p} = \frac{1}{6} + \frac{1}{3} \text{ or } R_p = 2\ \Omega$$



The equivalent circuit diagram is given in figure. Total current in the circuit,

$$I = \frac{18}{2+4} = 3\text{ A}$$

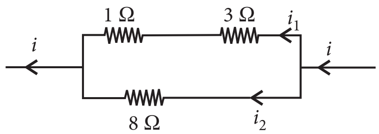
Power in the circuit = VI = 18 × 3 = 54 watt

52. (a) : Resistance of series combination of 3 Ω and 1 Ω is R_1 = 3 + 1 = 4 Ω, R_2 = 8 Ω

Let i be the total current in the circuit.

Current through R_1 is

$$i_1 = \frac{i\times R_2}{R_1 + R_2} = \frac{i\times 8}{12} = \frac{2i}{3}$$



$$\text{Current through } R_2 \text{ is } i_2 = \frac{i\times R_1}{R_1 + R_2} = \frac{i\times 4}{12} = \frac{i}{3}$$

Power dissipated in 3 Ω resistor is

$P_1 = i_1^2 \times 3$

Power dissipated in 8 Ω resistor is

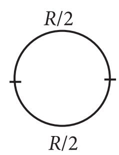
$P_2 = i_2^2 \times 8$

$$\therefore\ \frac{P_1}{P_2} = \frac{i_1^2\times 3}{i_2^2 \times 8} \text{ or, } \frac{P_1}{P_2} = \frac{(2i/3)^2\times 3}{(i/3)^2\times 8} = \frac{12}{8} = \frac{3}{2}$$

$$P_1 = \frac{3}{2}\times P_2 = \frac{3}{2}\times 2 = 3\text{ watt}$$

∴ Power dissipated across 3 Ω resistor is 3 watt.

53. (a) : Both are in parallel.



$$\frac{1}{R'} = \frac{2}{R} + \frac{2}{R} = \frac{4}{R} \Rightarrow R' = \frac{R}{4}$$

54. (a) : When n resistance of r ohm connected in parallel then their equivalent resistance is

$$\frac{1}{R} = \frac{1}{r} + \frac{1}{r} + \frac{1}{r} + \text{............} n \text{ times}$$

$$\therefore\ \frac{1}{R} = \frac{n}{r} \Rightarrow R = \frac{r}{n} \Rightarrow r = nR$$

When these resistance connected in series

$R_s = r + r + \text{................} n$ times

$= nr = n \times nR = n^2R$

$$\textbf{55. (d) :} \text{ The resistance of each bulb} = \frac{V^2}{P} = \frac{(200)^2}{60}\ \Omega$$

When three bulbs are connected in series their resultant

$$\text{resistance } = \frac{3\times(200)^2}{60}\ \Omega$$

Thus power drawn by bulb when connected across 200 V supply

$$P = \frac{V^2}{R_{re}} = \frac{(200)^2}{3\times(200)^2/60} = 20 \text{ W}$$

56. (d) : $R = \frac{V^2}{P} = \frac{220\times220}{100} = 484\,\Omega$

In series, $R_{eq} = 484 + 484 = 968\ \Omega$

$$\therefore\ P_{eq} = \frac{V^2}{968} = \frac{220\times220}{968} = 50 \text{ watt}$$

In parallel, $R_{eq} = 242\ \Omega$

$$\therefore\ P_{eq} = \frac{V^2}{242} = \frac{220\times220}{242} = 200 \text{ watt.}$$

57. (a) : Let R_1 and R_2 be the resistance of the two coils and V be the voltage supplied.

Effective resistance of two coils in parallel $= \frac{R_1R_2}{R_1+R_2}$

Let H be the heat required to begin boiling in kettle.

Then $H =$ Power $\times$ time $= \frac{V^2t_1}{R_1} = \frac{V^2t_2}{R_2}$

For parallel combination, $H = \frac{V^2(R_1+R_2)t_p}{R_1R_2}$

$$\Rightarrow\ \frac{1}{t_p} = \left(\frac{t_2+t_1}{t_2\,t_1}\right)$$

$$\therefore\ t_p = \frac{t_1t_2}{t_1+t_2} = \frac{10\times40}{10+40} = 8 \text{ minutes}$$

58. (d) : In given circuit R_B and R_C are in series.

$\therefore\ R_{BC} = 6 + 6 = 12\ \Omega.$

Now, R_A and R_{BC} are in parallel.

Therefore, equivalent resistance of circuit,

$$R_{eq} = \frac{12\times3}{12+3} = \frac{36}{15}\,\Omega$$

Using Ohm's law, $I = \frac{V}{R_{eq}} = \frac{4.8}{36/15} = 2 \text{ A}$

59. (d) : For series, $R_{eq} = 3r$

$$\text{Power} = \frac{V^2}{3r} = 10 \Rightarrow \frac{V^2}{r} = 30$$

For parallel $R_{eq} = r/3$

$$\text{Power} = \frac{V^2}{r/3} = \frac{3V^2}{r} = 3\times30 = 90 \text{ watt}$$

60. (b) : Applied voltage $(V) = 2$V and resistances $= 3\ \Omega, 3\ \Omega, 3\ \Omega$.

From the given circuit, we find that two resistances are in series and third resistance is in parallel. Therefore equivalent resistance for series resistances $= 3 + 3 = 6\ \Omega$. Now it is connected parallel with $3\ \Omega$ resistance. Therefore

$$\frac{1}{R} = \frac{1}{3} + \frac{1}{6} = \frac{3}{6} = \frac{1}{2} \text{ or } R = 2\,\Omega$$

And current flowing in the circuit $(I) = \frac{V}{R} = \frac{2}{2} = 1 \text{ A}$

61. (d) : Ratio of resistance $R_1 : R_2 = 1 : 2$ or $\frac{R_1}{R_2} = \frac{1}{2}$

In series combination, power dissipated $(P) = I^2R$

Therefore $\frac{P_1}{P_2} = \frac{R_1}{R_2} = \frac{1}{2}$ or $P_1 : P_2 = 1 : 2$

62. (a) : Lower resistance on extreme left and upper resistance on extreme right are ineffective.

The resistance R_2 and R_3 are in series combination. Therefore their equivalent resistance,

$$R' = R_2 + R_3 = 10 + 10 = 20\ \Omega$$

Similarly, the resistance R_5 and R_6 are in series combination. Therefore their equivalent resistance,

$$R'' = R_5 + R_6 = 10 + 10 = 20\ \Omega$$

Now the equivalent resistances R' and R'' are in parallel combination. Therefore their equivalent resistance,

$$R''' = \frac{R'R''}{R'+R''} = \frac{20\times20}{20+20} = \frac{400}{40} = 10\,\Omega$$

Thus equivalent resistance between A and D,

$R = R_1 + R''' + R_4 = 10 + 10 + 10 = 30\ \Omega$

63. (a) : Ratio of cross-sectional areas of the wires = 3 : 1 and resistance of thick wire $(R_1) = 10\ \Omega$

$$\text{Resistance}(R) = \rho\,\frac{l}{A} \propto \frac{1}{A}$$

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

and equivalent resistance of these two resistances in series combination

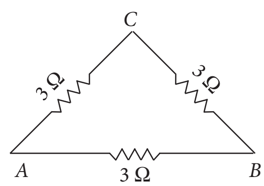
$$= R_1 + R_2 = 30 + 10 = 40\ \Omega$$

64. (b) : Power of heating coil = 100 W and voltage (V) = 220 volts. When the heating coil is cut into two equal parts and these parts are joined in parallel, the resistance of the coil is reduced to one-fourth of the previous value. Therefore energy liberated per second becomes 4 times. *i.e.* 4 × 100 = 400 W.

65. (a) : Resistances R_{AF} and R_{FE} are in series combination. Therefore their equivalent resistance $R' = R_{AF} + R_{FE} = 3 + 3 = 6\ \Omega$. Now the resistance R_{AE} and equivalent resistance R' are in parallel combination. Therefore relation for their equivalent resistance

$$\frac{1}{R''} = \frac{1}{R'} + \frac{1}{R_{AE}} = \frac{1}{6} + \frac{1}{6} = \frac{2}{6} = \frac{1}{3} \Rightarrow R'' = 3\,\Omega$$

We can reduce the circuit in similar way and finally the circuit reduces as shown in the figure.



Therefore, the equivalent resistance between A and B

$$= \frac{(3+3)\times3}{(3+3)+3} = \frac{18}{9} = 2\,\Omega$$

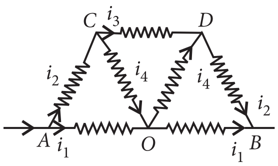
66. (d) : The two resistances are connected in series and the resultant is connected in parallel with the third resistance.

$\therefore \; R = 4\,\Omega + 4\,\Omega = 8\,\Omega$ and $\frac{1}{R''} = \frac{1}{8} + \frac{1}{4} = \frac{3}{8}$

or $R'' = \frac{8}{3}\,\Omega$

67. (c) : Current across 3 Ω = 0.8 A
6 Ω is in parallel, current across 6 Ω = 0.4 A
Total current = 1.2 A
∴ Potential difference across 4 Ω resistor
= 1.2 A × 4 Ω = 4.8 V

68. (d) :



By symmetry, currents i_1 and i_2 from A is the same as i_1 and i_2 reaching B.
As the same current is flowing from A to O and O to B, O can be treated as detached from AB.
Now CO and OD will be in series hence its total resistance = 2 Ω
It is in parallel with CD so equivalent resistance

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

This equivalent resistance is in series with AC and DB. So total resistance $= \frac{2}{3} + 1 + 1 = \frac{8}{3}\,\Omega$

Now $\frac{8}{3}\,\Omega$ is parallel to AB that is 2 Ω. So total resistance

$$= \frac{(8/3)\times 2}{(8/3)+2} = \frac{16/3}{14/3} = \frac{16}{14} = \frac{8}{7}\,\Omega$$

69. (c) : To carry a current of 4 ampere, we need four paths, each carrying a current of one ampere. Let r be the resistance of each path. These are connected in parallel. Hence their equivalent resistance will be $r/4$. According to the given problem $\frac{r}{4} = 5$ or $r = 20\,\Omega$
For this purpose two resistances should be connected in series. There are four such combinations that are connected in parallel. Hence, the total number of resistance = 4 × 2 = 8

70. (b) : Since, the supply voltage is same for the two combinations, the net resistance is less for 39 bulbs. Hence the combination of 39 bulbs will glow more as current is more.

71. (c) : In series $R_s = nR$

In parallel $\frac{1}{R_p} = \frac{1}{R} + \frac{1}{R} + ...n \text{ terms} = \frac{n}{R}$

$\Rightarrow \quad R_p = \frac{R}{n} \quad \therefore \; R_s / R_p = n^2/1$

72. (a) : Current drawn from a battery when n resistors are connected in series is

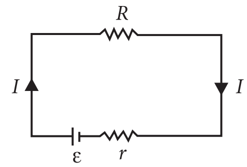
$$I = \frac{E}{nR + R} \qquad ...(i)$$

Current drawn from same battery when n resistors are connected in parallel is

$$10I = \frac{E}{R/n + R} \qquad ...(ii)$$

On dividing eqn. (ii) by (i), $10 = \frac{(n+1)R}{(1/n+1)R}$
After solving the equation, $n = 10$

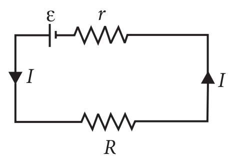
73. (d) : $I = \frac{\varepsilon}{R+r}$ or $IR + Ir = \varepsilon$



Here, $R = 10\,\Omega$, $r = ?$,
$\varepsilon = 2.1$ V, $I = 0.2$ A
∴ $0.2 \times 10 + 0.2 \times r = 2.1$
$2 + 0.2r = 2.1$
$0.2r = 0.1$ or $r = \frac{1}{2} = 0.5\,\Omega$

74. (c) : Current in the circuit, $I = \frac{\varepsilon}{R+r}$

Potential difference across R,

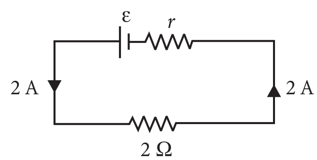


$$V = IR = \left(\frac{\varepsilon}{R+r}\right)R$$

$$V = \frac{\varepsilon}{1 + \frac{r}{R}}$$

When $R = 0$, $V = 0$; $R = \infty$, $V = \varepsilon$
Hence, option (c) represents the correct graph.

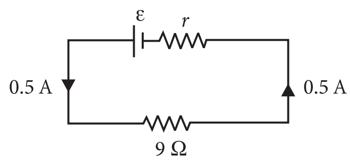
75. (b) : Let ε be the emf and r be internal resistance of the battery.



In the first case,

$$2 = \frac{\varepsilon}{2+r} \qquad ...(i)$$

In the second case,



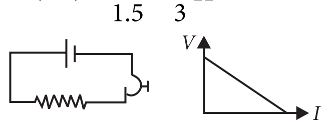
$$0.5 = \frac{\varepsilon}{9+r} \qquad ...(ii)$$

Divide (i) by (ii), we get

$$\frac{2}{0.5} = \frac{9+r}{2+r} \;\Rightarrow\; 4 + 2r = 4.5 + 0.5r$$

$$1.5r = 0.5 \;\Rightarrow\; r = \frac{0.5}{1.5} = \frac{1}{3}\,\Omega$$

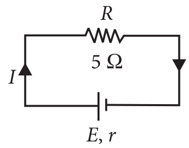
76. (a) :



$V = \varepsilon - Ir$, comparing with $y = c - mx$
∴ Slope = $-r$, internal resistance
V_{max} = emf ε. This is intercept on the y-axis.
As I decreases as R increases, so slope is negative.

77. (a) : Terminal potential difference is 2.2 V when circuit is open.

$\therefore$ e.m.f. of the cell = E = 2.2 volt



Now, when the cell is connected to the external resistance, current in the circuit I is given by

$I = \frac{E}{R+r} = \frac{2.2}{5+r}$ ampere, where r is the internal resistance of the cell.

Potential difference across the cell = IR

or, $\frac{2.2}{5+r} \times 5 = 1.8$ or, $5 + r = 11/1.8$

$\therefore \quad r = \frac{11}{1.8} - 5 = \frac{110-90}{18} = \frac{10}{9}\,\Omega$

78. (c) : $\frac{V-E}{r} = I \Rightarrow \frac{V-12}{5\times10^{-2}} = 60$

$\Rightarrow \quad V = 15$ V

79. (a) : $i = \frac{2}{4} = 0.5$ Ampere

$V = \varepsilon - ir = 2 - 0.5 \times 0.1 = 1.95$ V

80. (a) : The output power of a cell is given by

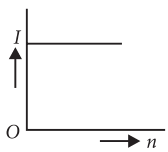
$$P = \frac{V^2}{(r+R)^2}R$$

Maximum power is delivered to the load only when the internal resistance of the source is equal to the load resistance (R). Then

$$P_{max} = \frac{V^2}{4R} = \frac{V^2}{4r} \qquad \text{(where } r = R)$$

81. (a) : Current drawn from the cell is

$$I = \frac{n\varepsilon}{nr} = \frac{\varepsilon}{r}$$



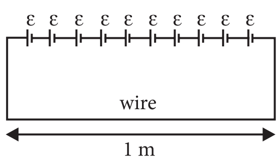
So, I is independent of n and I is constant.

82. (a) : Let ρ be resistivity of the material of the wire and r be radius of the wire.

Therefore, resistance of 1 m wire is

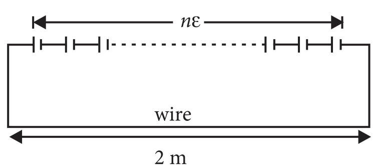
$$R = \frac{\rho(1)}{\pi r^2} = \frac{\rho}{\pi r^2} \qquad \left(\because R = \frac{\rho l}{A}\right)$$

Let ε be emf of each cell. In first case, 10 cells each of emf ε are connected in series to heat the wire of length 1 m by $\Delta T(= 10°C)$ in time t.



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

In second case, resistance of same wire of length 2 m is



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

Let n cells each of emf ε are connected in series to heat the same wire of length 2 m, by the same temperature ΔT (= 10°C) in the same time t.

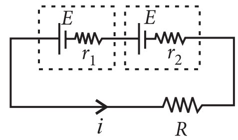
$$\therefore \quad \frac{(n\varepsilon)^2 t}{2R} = (2m)s\Delta T \qquad \ldots\text{(ii)}$$

Divide (ii) by (i), we get

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

83. (b) : Current in the circuit,

$$i = \frac{2E}{(r_1 + r_2 + R)}.$$



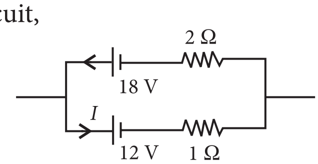
As per question, $E - ir_1 = 0$

$i = \frac{E}{r_1}$ or, $\frac{2E}{r_1 + r_2 + R} = \frac{E}{r_1}$

or, $2r_1 = r_1 + r_2 + R$ or, $R = r_1 - r_2$

84. (d) : Current in the circuit,

$$I = \frac{V}{R} = \frac{6}{3} = 2\text{ A}$$



Voltage drop across 2 Ω,

$V_1 = 2 \times 2 = 4$ V

Voltmeter reading = 18 – 4 = 14 V

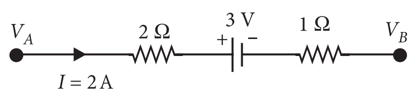
85. (b) : For maximum current, the two batteries should be connected in series. The current will be maximum when external resistance is equal to the total internal resistance of cells *i.e.* 2 Ω. Hence power developed across the resistance R will be

$$I^2R = \left(\frac{2E}{R+2r}\right)^2 R = \left(\frac{2\times2}{2+2}\right)^2 \times 2 = 2\text{ W}$$

86. (a) : $I = \frac{8-4}{1+2+9} = \frac{4}{12} = \frac{1}{3}$ A

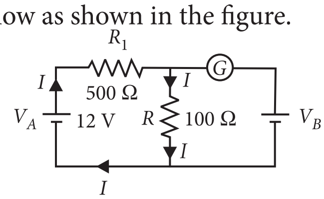
$$V_P - V_Q = 4 - \frac{1}{3}\times3 = 3\text{ volt}$$

87. (d) :



$V_{AB} = V_A - V_B = 2 \times 2 + 3 + 1 \times 2 = 9$ V

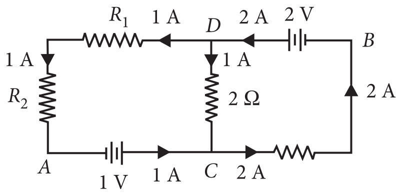
88. (b) : Since the galvanometer shows no deflection so current will flow as shown in the figure.



$$\text{Current, } I = \frac{V_A}{R_1 + R} = \frac{12\text{ V}}{(500+100)\,\Omega} = \frac{12}{600}\text{ A}$$

$$V_B = IR = \left(\frac{12}{600}\text{ A}\right)(100\,\Omega) = 2\text{ V}$$

89. (a) :



Applying Kirchhoff's voltage law a long path *ACDB* as shown in the figure.

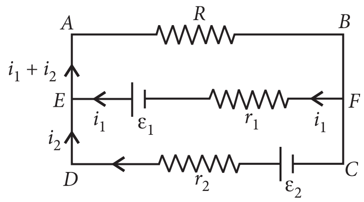
$\therefore \quad V_A + 1 + 2(1) - 2 = V_B$

$0 + 1 = V_B \qquad (\because\ V_A = 0\text{ V (Given)})$

$V_B = +1\text{ V}$

90. (d) : Kirchhoff's junction law or Kirchhoff's first law is based on the conservation of charge.
Kirchhoff's loop law or Kirchhoff's second law is based on the conservation of energy.
Hence both statements (A) and (B) are correct.

91. (d) :



Applying Kirchhoff's equation to the loop *ABFE*,

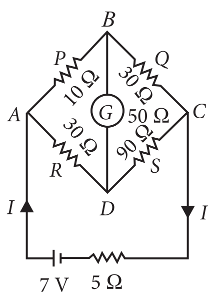
$-(i_1 + i_2)R - i_1r_1 + \varepsilon_1 = 0$

or $\quad \varepsilon_1 - (i_1 + i_2)R - i_1r_1 = 0$

92. (c) : Kirchhoff's first law of electrical circuit is based on conservation of charge and Kirchhoff's second law of electrical circuit is based on conservation of energy.

93. (c)

94. (d) : The situation is as shown in the figure. For a balanced Wheatstone's bridge



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

$$\therefore \quad \frac{10\,\Omega}{30\,\Omega} = \frac{30\,\Omega}{90\,\Omega} \text{ or } \frac{1}{3} = \frac{1}{3}$$

It is a balanced Wheatstone's bridge. Hence no current flows in the galvanometer arm. Hence, resistance 50 Ω becomes ineffective.

$\therefore$ The equivalent resistance of the circuit is

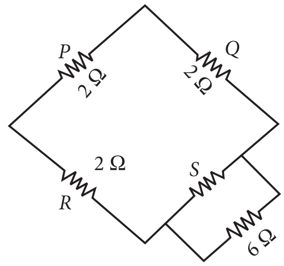
$$R_{eq} = 5\,\Omega + \frac{(10\,\Omega + 30\,\Omega)\,(30\,\Omega + 90\,\Omega)}{(10\,\Omega + 30\,\Omega) + (30\,\Omega + 90\,\Omega)}$$

$$= 5\,\Omega + \frac{(40\,\Omega)(120\,\Omega)}{40\,\Omega + 120\,\Omega} = 5\,\Omega + 30\,\Omega = 35\,\Omega$$

Current drawn from the cell is

$$I = \frac{7\text{ V}}{35\,\Omega} = \frac{1}{5}\text{ A} = 0.2\text{ A}$$

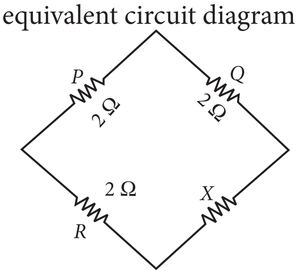
95. (a) :



Let *X* be the equivalent resistance between *S* and 6 Ω.

$$\therefore \quad \frac{1}{X} = \frac{1}{S} + \frac{1}{6} \qquad \text{... (i)}$$

Therefore, the equivalent circuit diagram drawn here



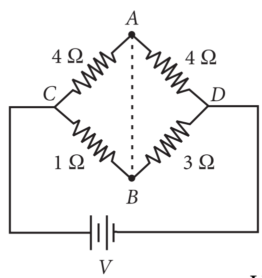
For a balanced Wheatstone's bridge, we get

$$\frac{P}{Q} = \frac{R}{X} \text{ or } \frac{2}{2} = \frac{2}{X} \Rightarrow X = 2\ \Omega.$$

From eqn. (i), we get

$$\frac{1}{2} = \frac{1}{S} + \frac{1}{6} \quad \text{or,} \quad \frac{1}{S} = \frac{2}{6} \quad \text{or,} \quad S = 3\ \Omega$$

96. (a) :



Current through arm *CAD*, $I = \frac{V}{8}$ amp

Potential difference between *C* and *A* = $V_C - V_A$

$$= \frac{V}{8} \times 4 = \frac{V}{2} \text{ volt}$$

Current through *CBD*, $I' = \frac{V}{4}$ amp

Potential difference between *C* and *B* = $V_C - V_B$

$$= \frac{V}{4} \times 1 = \frac{V}{4} \text{ volt.}$$

Potential between *A* and *B* = $V_A - V_B$

$$\therefore \quad V_A - V_B = V_C - V_B - (V_C - V_A) = \frac{V}{4} - \frac{V}{2} = -\frac{V}{4}.$$

$\Rightarrow \quad V_A - V_B < 0$ or, $V_A < V_B$

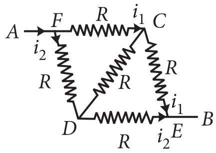
As $V_A < V_B$, so direction of current will be from *B* to *A*.

97. (d) : Since given circuit is in the form of Wheatstone bridge,

$$\frac{1}{R_{eq}}=\frac{1}{(4+2)}+\frac{1}{(6+3)};\ R_{eq}=18/5\,\Omega$$

$$V=iR_{eq}\ \Rightarrow\ i=\frac{V}{R_{eq}}=\frac{5V}{18}$$

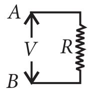
98. (c) : Equivalent circuit of given circuit is shown in figure (i).



Figure(i)

Also this is equivalent to a balanced Wheatstone bridge C and D are at equal potential, no current will flow in this resistance therefore this resistance can be neglected.

Thus equivalent resistance of this remaining circuit shown in figure (ii) is R.

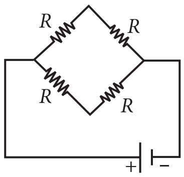


Figure(ii)

Then current in $AFCEB$ branch is

$$i_1=\frac{V}{R}\times\frac{2R}{2R+2R}=\frac{V}{2R}$$

99. (c) : In balance Wheatstone bridge, the galvanometer arm can be neglected. So equivalent resistance will be



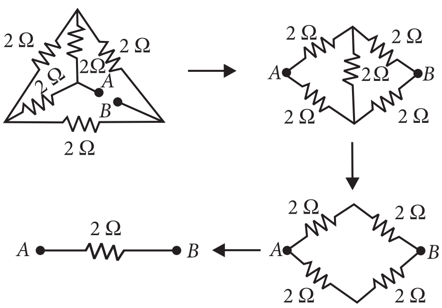
$$\frac{2R\times 2R}{2R+2R}=\frac{4R^2}{4R}=R$$

100. (a)

101. (b) : This is a balanced Wheatstone's bridge so no current flows through the 7 Ω resistor.

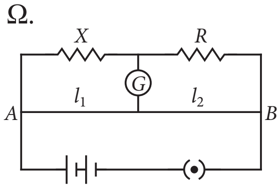
$$\therefore\ \frac{1}{R_{eq}}=\frac{1}{4+3}+\frac{1}{6+8}\ \text{or}\ R_{eq}=\frac{14}{3}\,\Omega$$

102. (d) : The circuit is equivalent to a balanced Wheatstone bridge. Therefore resistance between A and B is 2 Ω.



103. (b) : Unknown is X, R = 10 Ω.

Here, $\frac{l_1}{l_2}=\frac{3}{2};\ \frac{X}{R}=\frac{l_1}{l_2}$

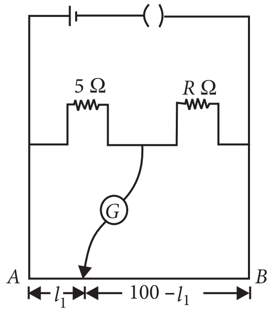


$\Rightarrow X=\frac{3}{2}\times 10\Rightarrow X=15\ \Omega$

Thus, 1.5 m length has resistance 15 Ω hence, length of 1 Ω of the resistance wire $=\frac{1.5}{15}=0.1\text{ m }=1.0\times 10^{-1}\text{ m}$

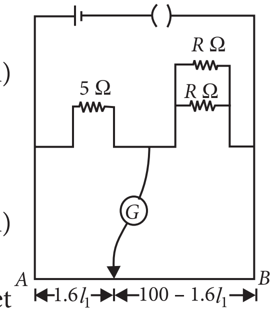
104. (d) : Yes, the bridge will work. For a balanced condition, the current drawn from the battery will be zero. Also, $P\propto l_1$ and $Q\propto l_2$ Therefore, the condition $\frac{P}{Q}=\frac{l_1}{l_2}$ will remain same after interchanging the cell and galvanometer.

105. (b) : In the first case,



At balance point

$$\frac{5}{R}=\frac{l_1}{100-l_1}\qquad\text{...(i)}$$



In the second case,

At balance point

$$\frac{5}{(R/2)}=\frac{1.6l_1}{100-1.6l_1}\qquad\text{...(ii)}$$

Divide eqn. (i) by eqn. (ii), we get

$$\frac{1}{2}=\frac{100-1.6l_1}{1.6(100-l_1)}$$

or $160-1.6l_1=200-3.2l_1$

$$1.6l_1=40\ \text{or}\ l_1=\frac{40}{1.6}=25\text{ cm}$$

Substituting this value in eqn. (i), we get

$$\frac{5}{R}=\frac{25}{75}\ \text{or}\ \ R=\frac{375}{25}\,\Omega=15\,\Omega$$

106. (d) : Metre bridge works on the principle of Wheatstone's bridge.

$$\therefore\ \frac{P}{Q}=\frac{l}{100-l}\ \text{ or, }P=\frac{l}{100-l}\times Q=\frac{20}{80}\times 1=0.25\,\Omega.$$

107. (b) : A potentiometer is an accurate and versatile device to make electrical measurement of emf because the method involves a condition of no current flow through the galvanometer. The device can be used to measure potential difference, internal resistance of a cell and compare emf's of two sources.

108. (b) : Suppose two cells have emfs ε_1 and ε_2 (also $\varepsilon_1>\varepsilon_2$). Potential difference per unit length of the potentiometer wire = k (say)

When ε_1 and ε_2 are in series and support each other then

$$\varepsilon_1+\varepsilon_2=50\times k\qquad\text{...(i)}$$

When ε_1 and ε_2 are in opposite direction

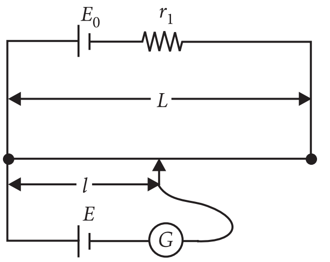
$$\varepsilon_1-\varepsilon_2=10\times k\qquad\text{...(ii)}$$

On adding eqn. (i) and eqn. (ii)

$2\varepsilon_1 = 60k \Rightarrow \varepsilon_1 = 30k$ and $\varepsilon_2 = 50k - 30k = 20k$

$$\therefore \quad \frac{\varepsilon_1}{\varepsilon_2} = \frac{30k}{20k} = \frac{3}{2}$$

109. (d) :



The current through the potentiometer wire is $I = \dfrac{E_0}{(r+r_1)}$ and the potential difference across the wire is

$$V = Ir = \frac{E_0 r}{(r+r_1)}$$

The potential gradient along the potentiometer wire is

$$k = \frac{V}{L} = \frac{E_0 r}{(r+r_1)L}$$

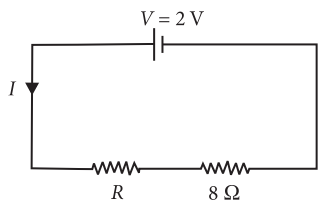
As the unknown e.m.f. E is balanced against length l of the potentiometer wire,

$$\therefore \quad E = kl = \frac{E_0 r}{(r+r_1)}\frac{l}{L}$$

110. (c) : Required potential gradient = 1 mV cm^{-1}

$$= \frac{1}{10}\ \text{Vm}^{-1}$$

Length of potentiometer wire, $l = 4$ m



So potential difference across potentiometer wire

$$= \frac{1}{10} \times 4 = 0.4\ \text{V} \qquad \ldots\text{(i)}$$

In the circuit, potential difference across 8 Ω

$$= I \times 8 = \frac{2}{8+R} \times 8 \qquad \ldots\text{(ii)}$$

Using equation (i) and (ii), we get, $0.4 = \dfrac{2}{8+R} \times 8$

$$\frac{4}{10} = \frac{16}{8+R} \text{ or } 8 + R = 40 \ \therefore\ R = 32\ \Omega$$

111. (c) : The internal resistance of the cell is

$$r = \left(\frac{l_1}{l_2} - 1\right)R$$

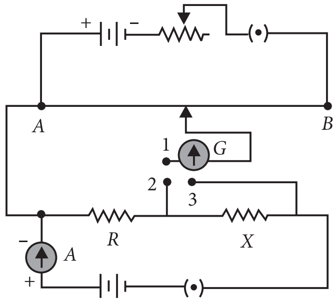
Here, $l_1 = 3$ m, $l_2 = 2.85$ m, $R = 9.5\ \Omega$

$$\therefore \quad r = \left(\frac{3}{2.85} - 1\right)(9.5\ \Omega) = \frac{0.15}{2.85} \times 9.5\ \Omega = 0.5\ \Omega$$

112. (b) : When the two way key is switched off, then The current flowing in the resistors R and X is

$$I = 1\ \text{A} \qquad \ldots\text{(i)}$$

When the key between the terminals 1 and 2 is plugged in, then



potential difference across $R = IR = kl_1$ ...(ii)

where k is the potential gradient across the potentiometer wire.

When the key between the terminals 1 and 3 is plugged in, then potential difference across $(R + X) = I(R + X) = kl_2$ ...(iii)

From equation (ii), we get

$$R = \frac{kl_1}{I} = \frac{kl_1}{1} = kl_1\ \Omega \qquad \ldots\text{(iv)}$$

From equation (iii), we get

$$R + X = \frac{kl_2}{I} = \frac{kl_2}{1} = kl_2\ \Omega \qquad \text{(Using (i))}$$

$$X = kl_2 - R = kl_2 - kl_1 \qquad \text{(Using (iv))}$$

$$= k(l_2 - l_1)\ \Omega$$

113. (c) : [In the question, the length 110 cm and 100 cm are interchanged as $\varepsilon > \dfrac{\varepsilon R}{R+r}$]

Without being short circuited through R, only the battery ε is balanced.

$$\varepsilon = \frac{V}{L} \times l_1 = \frac{V}{L} \times 110\ \text{cm} \qquad \ldots\text{(i)}$$

When R is connected across ε,

$$Ri = R \cdot \left(\frac{\varepsilon}{R+r}\right) = \frac{V}{L} \times l_2 \ \Rightarrow\ \frac{R\varepsilon}{R+r} = \frac{V}{L} \times 100 \qquad \ldots\text{(ii)}$$

Dividing eqn. (i) and (ii), $\dfrac{(R+r)}{R} = \dfrac{110}{100}$

$$\Rightarrow\ 1 + \frac{r}{R} = \frac{110}{100} \Rightarrow \frac{r}{R} = \frac{110}{100} - \frac{100}{100}$$

$$\Rightarrow\ r = R \cdot \frac{10}{100} = \frac{R}{10}. \quad \text{As } R = 10\ \Omega;\ r = 1\ \Omega$$

114. (a) : $\dfrac{V}{l} = \dfrac{IR}{l} = \dfrac{I\rho l}{Al} = \dfrac{0.1 \times 10^{-7}}{10^{-6}}$

$= 0.01 = 10^{-2}$ V/m

115. (d)

116. (c) : $i = \dfrac{2}{10} = 0.2$ A, $\dfrac{R}{l} = \dfrac{10}{4}$

Potential difference per unit length

$= 0.2 \times (10/4) = 0.5$ V/m

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