CHAPTER

12 Electricity

12.1 Electric Current and Circuit

12.2 Electric Potential and Potential Difference

12.3 Circuit Diagram

12.4 Ohm's Law

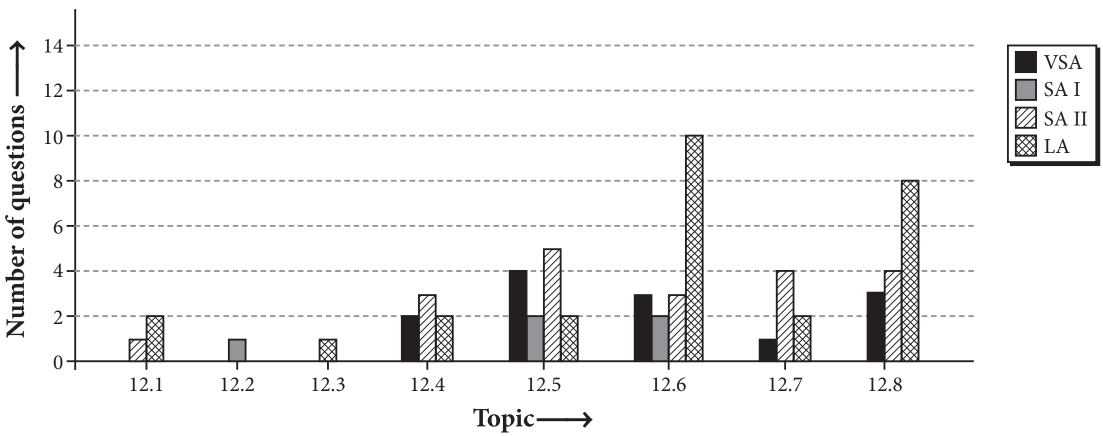
12.5 Factors on which the Resistance of a Conductor Depends

12.6 Resistance of a System of Resistors

12.7 Heating Effect of Electric Current

12.8 Electric Power

Topicwise Analysis of Last 10 Years' CBSE Board Questions (2020-2011)



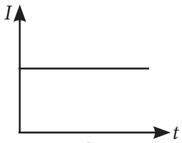
- Maximum weightage is of *Resistance of a System of Resistors.*
- Maximum SA II type questions were asked from *Factors on which the Resistance of a Conductor Depends.*

QUICK RECAP

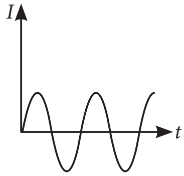
- **Charge :** Electrons have a negative charge of 1.6×10^{-19} C, while protons have an equal positive charge of 1.6×10^{-19} C.
- **Electric current :** The quantity of electric charge flowing through a conductor in one second.

$$\text{Current } (I) = \frac{\text{Charge } (Q)}{\text{Time } (t)}$$

- SI unit of current $= \dfrac{1 \text{ coulomb (C)}}{1 \text{ second (s)}}$ $= 1$ ampere (A)
- Small units of current are
  $1 \text{ mA} = 10^{-3}$ A (mA = milliampere)
  $1\ \mu\text{A} = 10^{-6}$ A (μA = microampere)
- Current may be direct, varying or alternating current.



Direct Current



Alternating Current

- **Electric potential :** The work done in bringing a unit positive charge from reference point to a point against any electric field.

$$V = \frac{\text{Work done } (W)}{\text{Charge } (q)}$$

▸ SI unit of electric potential

$$= \frac{1 \text{ joule (J)}}{1 \text{ coulomb (C)}} = 1 \text{ volt (V)}$$

- **Electric potential difference :** The amount of work done in bringing unit positive charge from one point to another point in an electric field.

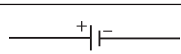
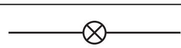
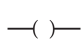
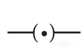
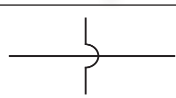
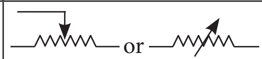
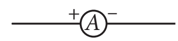
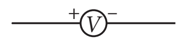
$$V_{AB} = V_B - V_A = \frac{W_B}{q} - \frac{W_A}{q}$$

▸ It has the same SI unit as electric potential.

- **Electric potential energy :** The work required to be done to bring the charges to their respective location against the electric field with the help of a source of energy.

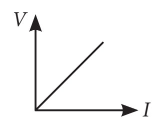
▸ This work done gets stored in the form of potential energy of charges.

- **Symbols of electrical components :** The symbols of the components that are used in making an electric circuit.

Component	Symbol
1. Electric cell	
2. Battery	
3. Lamp	
4. Electric bulb	
5. Key (open)	
6. Key (closed)	
7. Wire crossing	
8. Resistor	
9. Rheostat	
10. Ammeter	
11. Voltmeter	
12. Galvanometer	
13. AC source	

- **Ohm's law :** Under similar physical conditions, the current flowing through a conductor is directly proportional to the difference in potential applied across its ends, *i.e.*, $I \propto V$ or $V = IR$, where R is the resistance offered.

- **Graphical representation :**



Slope $\frac{V}{I}$ is a measure of resistance offered (R).

▸ The opposition caused to the flow of current is called resistance.

▸ The SI unit of resistance is ohm.

$$R = \frac{1 \text{ volt}}{1 \text{ ampere}} = 1 \text{ ohm } (\Omega)$$

- **Factors affecting resistance :**

▸ **Length of the conductor :** The resistance of a conductor is directly proportional to the length of the conductor.
$R \propto l$

▸ **Area of cross-section of the conductor :** The resistance of a conductor is inversely proportional to the area of the conductor.
$R \propto 1/A$

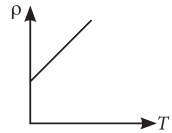
▸ **Material of the conductor :** Two resistance made up of the same length and same area of cross-section but of different materials have different resistances.

$$R \propto \frac{l}{A}; R = \rho\frac{l}{A} \text{ or } \rho = \frac{RA}{l}$$

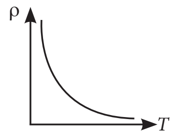
▸ Resistivity, $\rho = \frac{\text{ohm m}^2}{\text{m}} = \text{ohm m } (\Omega \text{ m})$

▸ **Temperature :** With rise in temperature, the resistance of metals increases and decreases with decrease in temperature. Certain alloy like nichrome, manganin whose resistance vary negligible with temperature.

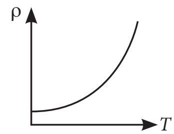
Effect of temperature on resistivity :



- Resistivity of a conductor increases linearly with increasing temperature.



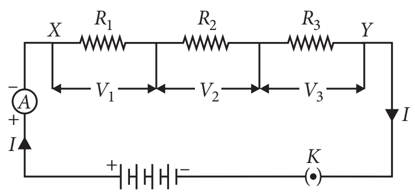
- Resistivity of a semi-conductor decreases with increase in temperature.



- Resistivity increases with rise in temperature in insulators.

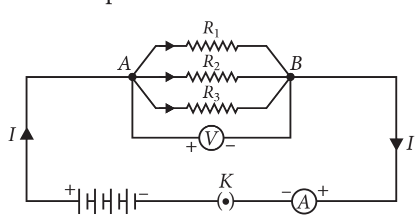
Combination of resistances :

- **Resistors in series :** When resistors are placed in series.



– The current through them will be the same.
– The sum of the potential difference, or voltage across them is the total potential difference, *i.e.*,
$V = V_1 + V_2 + V_3 = I(R_1 + R_2 + R_3)$
– The equivalent resistance is given by,
$R_S = R_1 + R_2 + R_3$

- **Resistors in parallel :** When resistors are connected in parallel.



– The potential difference across their ends is the same.
– The sum of current through them is the current drawn from the source of energy or cell.

$$I = I_1 + I_2 + I_3 \text{ or } \frac{V}{R_P} = \frac{V}{R_1} + \frac{V}{R_2} + \frac{V}{R_3}$$

– The equivalent resistance is given by,

$$\frac{1}{R_P} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

Heating effect of electric current :

- When electric current flows through the resistive element, the flowing charges suffer resistance. Work has to be done to overcome this resistance which is converted into heat energy. The complete sequence is, electrical energy does work which converts into heat energy.
- **Joule's law of heating :** When a current I flows through a resistor R, heat is produced. The heat produced H depends directly on the square of the current, resistance and the time t for which the current is allowed to pass through the resistor, $H = I^2Rt$
This is called Joule's law of heating.

Electrical power : The rate at which electrical energy is consumed or dissipated is called electrical power.

$$\text{Power} = \frac{\text{Work done}}{\text{Time}} = \frac{W}{t}$$

$$P = VI = I^2R = \frac{V^2}{R} = \frac{qV}{t}$$

- Power is expressed in joule/second or watt.
- Practical unit of electrical power is horse power (h.p.).
1 h.p. = 746 W

Electrical energy :

- Electrical energy = Electrical power × time
- Commercial unit of energy is kilowatt hour (kW h).
- 1 kW h = 3.6×10^6 J

Electrical fuse : It is a safety device connected in series with the electric circuit. It is a wire made of a material whose melting point is very low.

- Fuse wires are made of copper or tin-lead alloy.
- When large current flows through a circuit and hence through fuse wire large amount of heat is produced. Due to this heat the fuse wire and the circuit is broken so that current stops flowing through the circuit. This saves the electric circuit from burning.

Previous Years' CBSE Board Questions

12.1 Electric Current and Circuit

SA II (3 marks)

1. A current of 10 A flows through a conductor for two minutes.
   (i) Calculate the amount of charge passed through any area of cross section of the conductor.
   (ii) If the charge of an electron is 1.6×10^{-19} C, then calculate the total number of electrons flowing. *(Board Term I, 2013)*

LA (5 marks)

2. Define electric current. *(1/5, Board Term I, 2017)*
3. Define one ampere. *(1/5, Board Term I, 2015)*

12.2 Electric Potential and Potential Difference

SA I (2 marks)

4. Name a device that you can use to maintain a potential difference between the ends of a conductor. Explain the process by which this device does so. *(Board Term I, 2013)*

12.3 Circuit Diagram

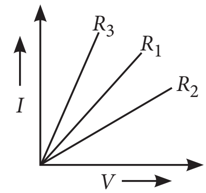
LA (5 marks)

5. Draw the symbols of commonly used components in electric circuit diagrams for
   (i) An electric cell
   (ii) Open plug key
   (iii) Wires crossing without connection
   (iv) Variable resistor
   (v) Battery
   (vi) Electric bulb
   (vii) Resistance *(4/5, Board Term I, 2017)*

12.4 Ohm's Law

VSA (1 mark)

6. A student plots *V-I* graphs for three samples of nichrome wire with resistances R_1, R_2 and R_3. Choose from the following the statements that holds true for this graph.

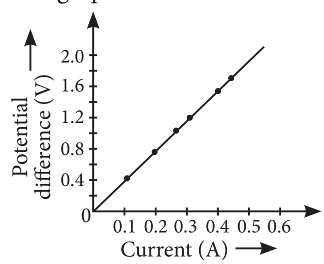


(a) $R_1 = R_2 = R_3$ (b) $R_1 > R_2 > R_3$
(c) $R_3 > R_2 > R_1$ (d) $R_2 > R_1 > R_3$ *(2020)*

7. State Ohm's law. *(AI 2019)*

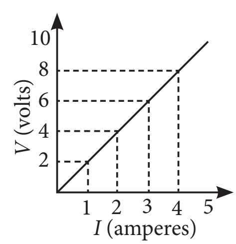
SA II (3 marks)

8. A *V-I* graph for a nichrome wire is given below. What do you infer from this graph? Draw a labelled circuit diagram to obtain such a graph.

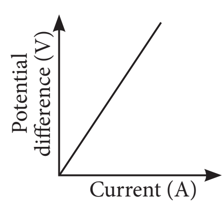


(2020)

9. Study the *V-I* graph for a resistor as shown in the figure and prepare a table showing the values of *I* (in amperes) corresponding to four different values *V* (in volts). Find the value of current for $V = 10$ volts. How can we determine the resistance of the resistor from this graph? *(Board Term I, 2016)*



10. *V-I* graph for a conductor is as shown in the figure



(i) What do you infer from this graph?
(ii) State the law expressed here.
(Board Term I, 2014)

LA (5 marks)

11. State Ohm's law. Draw a labelled circuit diagram to verify this law in the laboratory. If you draw a graph between the potential difference and current flowing through a metallic conductor, what kind of curve will you get? Explain how would you use this graph to determine the resistance of the conductor. *(Board Term I, 2016)*

12. State and explain Ohm's law. Define resistance and give its SI unit. What is meant by 1 ohm resistance? Draw *V-I* graph for an ohmic conductor and list its two important features. *(Board Term I, 2014)*

12.5 Factors on which the Resistance of a Conductor Depends

VSA (1 mark)

13. Assertion (A) : The metals and alloys are good conductors of electricity.
Reason (R) : Bronze is an alloy of copper and tin and it is not a good conductor of electricity.
(a) Both (A) and (R) are true and (R) is the correct explanation of the assertion (A).
(b) Both (A) and (R) are true, but (R) is not the correct explanation of the assertion (A).
(c) (A) is true, but (R) is false.
(d) (A) is false, but (R) is true. *(2020)*

14. A cylindrical conductor of length '*l*' and uniform area of cross section '*A*' has resistance '*R*'. The area of cross section of another conductor of same material and same resistance but of length '2*l*' is
(a) $\frac{A}{2}$ (b) $\frac{3A}{2}$
(c) $2A$ (d) $3A$ *(2020)*

15. Assertion (A) : Alloys are commonly used in electrical heating devices like electric iron and heater.
Reason (R) : Resistivity of an alloy is generally higher than that of its constituent metals but the alloys have low melting points then their constituent metals.
(a) Both (A) and (R) are true and (R) is the correct explanation of the assertion (A).
(b) Both (A) and (R) are true, but (R) is not the correct explanation of the assertion (A).
(c) (A) is true, but (R) is false.
(d) (A) is false, but (R) is true. *(2020)*

16. How is the resistivity of alloys compared with those of pure metals from which they may have been formed? *(Board Term I, 2017)*

SA I (2 marks)

17. (i) List three factors on which the resistance of a conductor depends.
(ii) Write the SI unit of resistivity.
(Board Term I, 2015)

18. Calculate the resistance of a metal wire of length 2 m and area of cross section 1.55×10^{-6} m^2, if the resistivity of the metal be 2.8×10^{-8} Ω m. *(Board Term I, 2013)*

SA II (3 marks)

19. (a) List the factors on which the resistance of a conductor in the shape of a wire depends.
(b) Why are metals good conductors of electricity whereas glass is a bad conductor of electricity ? Give reason.
(c) Why are alloys commonly used in electrical heating devices ? Give reason. *(2018)*

20. Calculate the resistivity of the material of a wire of length 1 m, radius 0.01 cm and resistance 20 ohms. *(Board Term I, 2017)*

21. A copper wire has diameter 0.5 mm and resistivity 1.6×10^{-8} Ω m. Calculate the length of this wire to make it resistance 100 Ω. How much does the resistance change if the diameter is doubled without changing its length? *(Board Term I, 2015)*

22. The resistance of a wire of 0.01 cm radius is 10 Ω. If the resistivity of the material of the wire is 50×10^{-8} ohm meter, find the length of the wire. *(Board Term I, 2014)*

23. A wire has a resistance of 16 Ω. It is melted and drawn into a wire of half its original length. Calculate the resistance of the new wire. What is the percentage change in its resistance? *(Board Term I, 2013)*

LA **(5 marks)**

24. If the radius of a current carrying conductor is halved, how does current through it change? *(2/5 Board Term I, 2014)*

25. Define resistance of a conductor. State the factors on which resistance of a conductor depends. Name the device which is often used to change the resistance without changing the voltage source in an electric circuit.
Calculate the resistance of 50 cm length of wire of cross sectional area 0.01 square mm and of resistivity $5 \times 10^{-8}\ \Omega$ m. *(Board Term I, 2014)*

12.6 Resistance of a System of Resistors

VSA **(1 mark)**

26. If a person has five resistors each of value $\frac{1}{5}\ \Omega$, then the maximum resistance he can obtain by connecting them is
(a) 1 Ω (b) 5 Ω
(c) 10 Ω (d) 25 Ω *(2020)*

27. The maximum resistance which can be made using four resistors each of 2 Ω is
(a) 2 Ω (b) 4 Ω
(c) 8 Ω (d) 16 Ω *(2020)*

28. The maximum resistance which can be made using four resistors each of resistance $\frac{1}{2}\ \Omega$ is
(a) 2 Ω (b) 1 Ω
(c) 2.5 Ω (d) 8 Ω *(2020)*

SA I **(2 marks)**

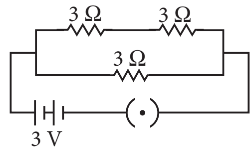
29. Three resistors of 10 Ω, 15 Ω and 5 Ω are connected in parallel. Find their equivalent resistance. *(Board Term I, 2014)*

30. List the advantages of connecting electrical devices in parallel with an electrical source instead of connecting them is series. *(Board Term I, 2013)*

SA II **(3 marks)**

31. Show how would you join three resistors, each of resistance 9 Ω so that the equivalent resistance of the combination is (i) 13.5 Ω, (ii) 6 Ω? *(2018)*

32. Three resistors of 3 Ω each are connected to a battery of 3 V as shown. Calculate the current drawn from the battery.



(Board Term I, 2017)

33. Two identical resistors are first connected in series and then in parallel. Find the ratio of equivalent resistance in two cases. *(Board Term I, 2013)*

LA **(5 marks)**

34. (a) A 6 Ω resistance wire is doubled on itself. Calculate the new resistance of the wire.
(b) Three 2 Ω resistors *A*, *B* and *C* are connected in such a way that the total resistance of the combination is 3 Ω. Show the arrangement of the three resistors and justify your answer. *(2020)*

35. Draw a schematic diagram of a circuit consisting of a battery of 3 cells of 2 V each, a combination of three resistors of 10 Ω, 20 Ω and 30 Ω connected in parallel, a plug key and an ammeter, all connected in series. Use this circuit to find the value of the following :
(a) Current through each resistor
(b) Total current in the circuit
(c) Total effective resistance of the circuit. *(2020)*

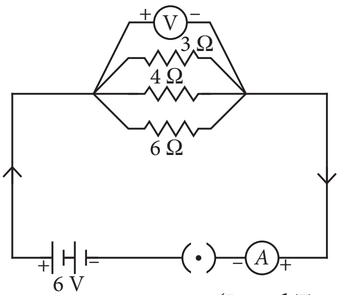
36. (a) With the help of a suitable circuit diagram prove that the reciprocal of the equivalent resistance of a group of resistances joined in parallel is equal to the sum of the reciprocals of the individual resistances.
(b) In an electric circuit two resistors of 12 Ω each are joined in parallel to a 6 V battery. Find the current drawn from the battery. *(Delhi 2019)*

37. For the series combination of three resistors establish the relation $R = R_1 + R_2 + R_3$ where the symbols have their usual meanings.
Calculate the equivalent resistance of the combination of three resistors of 6 Ω, 9 Ω and 18 Ω joined in parallel. *(Board Term I, 2016)*

38. State ohm's law. Represent it graphically. In the given circuit diagram calculate

(i) the total effective resistance of the circuit.

(ii) the current through each resistor.



(Board Term I, 2015)

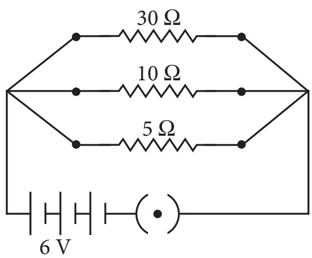
39. (a) Prove that the equivalent resistance of three resistors R_1, R_2 and R_3 in series is $R_1 + R_2 + R_3$.

(b) You have four resistors of 8 Ω each. Show how would you connect these resistors to have effective resistance of 8 Ω?

(4/5, Board Term I, 2015)

40. Draw a labelled circuit diagram showing three resistors R_1, R_2 and R_3 connected in series with a battery (E), a rheostat (Rh), a plug key (K) and an ammeter (A) using standard circuit symbols. Use this circuit to show that the same current flows through every part of the circuit. List two precautions you would observe while performing the experiment. *(Board Term I, 2014)*

41. Two wires A and B are of equal length and have equal resistances. If the resistivity of A is more than that of B, which wire is thicker and why ? For the electric circuit given below calculate:



(i) current in each resistor,

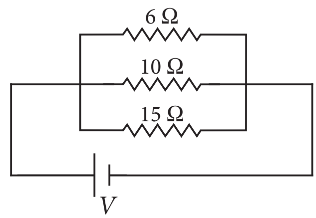
(ii) total current drawn from the battery, and

(iii) equivalent resistance of the circuit.

(Board Term I, 2014)

42. (a) Derive an expression to find the equivalent resistance of three resistors connected in series. Also draw the schematic diagram of the circuit.

(b) Find the equivalent resistance of the following circuit.



(Board Term I, 2013)

43. Draw a circuit diagram for a circuit consisting of a battery of five cells of 2 volts each, a 5 Ω resistor, a 10 Ω resistor and a 15 Ω resistor, an ammeter and a plug key; all connected in series. Also connect a voltmeter to record the potential difference across the 15 Ω resistor and calculate

(i) the electric current passing through the above circuit and

(ii) potential difference across 5 Ω resistor when the key is closed.

(Board Term I, 2013)

12.7 Heating Effect of Electric Current

VSA (1 mark)

44. The resistance of a resistor is reduced to half of its initial value. In doing so, if other parameters of the circuit remain unchanged, the heating effects in the resistor will become

(a) two times (b) half

(c) one-fourth (d) four times *(2020)*

SA II (3 marks)

45. (a) Write the mathematical expression for Joule's law of heating.

(b) Compute the heat generated while transferring 96000 coulomb of charge in two hours through a potential difference of 40 V.

(2020)

46. Write Joule's law of heating. *(1/3, 2018)*

47. Explain the use of an electric fuse. What type of material is used for fuse wire and why? *(Board Term I, 2016)*

48. (a) Why is tungsten used for making bulb filaments of incandescent lamps?
(b) Name any two electric devices based on heating effect of electric current. *(2/5, Board Term I, 2015)*

LA (5 marks)

49. A fuse wire melts at 5 A. If it is desired that the fuse wire of same material melt at 10 A, then whether the new fuse wire should be of smaller or larger radius than the earlier one? Give reasons for your answer. *(3/5, Board Term I, 2014)*

50. What is heating effect of current? List two electrical appliances which work on this effect. *(2/5, Board Term I, 2013)*

12.8 Electric Power

VSA (1 mark)

51. Two bulbs of 100 W and 40 W are connected in series. The current through the 100 W bulb is 1 A. The current through the 40 W bulb will be
(a) 0.4 A (b) 0.6 A
(c) 0.8 A (d) 1 A *(2020)*

52. Write the relation between resistance (R) of filament of a bulb, its power (P) and a constant voltage V applied across it. *(Board Term I, 2017)*

53. Power of a lamp is 60 W. Find the energy in joules consumed by it in 1s. *(Board Term I, 2016)*

SA II (3 marks)

54. Two lamps, one rated 100 W; 220 V, and the other 60 W; 220 V, are connected in parallel to electric mains supply. Find the current drawn by two bulbs from the line, if the supply voltage is 220 V. *(2/3, 2018, Board Term I, 2014)*

55. How much current will an electric iron draw from a 220 V source if the resistance of its element when hot is 55 ohms? Calculate the wattage of the electric iron when it operates on 220 volts. *(Board Term I, 2016)*

56. An electric iron has a rating of 750 W; 200 V. Calculate:
(i) the current required.
(ii) the resistance of its heating element.
(iii) energy consumed by the iron in 2 hours. *[Board Term I, 2015]*

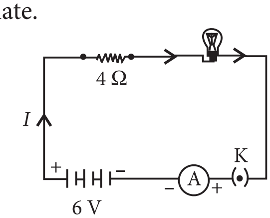
57. An electric bulb is connected to a 220 V generator. The current is 2.5 A. Calculate the power of the bulb. *(1/3, Board Term I, 2015)*

LA (5 marks)

58. (a) Define power and state its SI unit.
(b) A torch bulb is rated 5 V and 500 mA. Calculate its
(i) power
(ii) resistance
(iii) energy consumed when it is lighted for $2\frac{1}{2}$ hours. *(2020)*

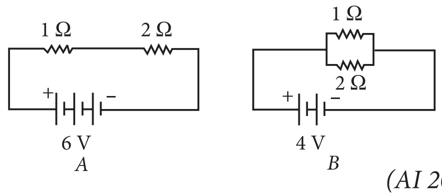
59. Two identical resistors, each of resistance 15 Ω, are connected in (i) series, and (ii) parallel, in turn to a battery of 6 V. Calculate the ratio of the power consumed in the combination of resistors in each case. *(2020)*

60. An electric lamp of resistance 20 Ω and a conductor of resistance 4 Ω are connected to a 6 V battery as shown in the circuit. Calculate.



(a) the total resistance of the circuit
(b) the current through the circuit,
(c) the potential difference across the (i) electric lamp and (ii) conductor, and
(d) power of the lamp. *(Delhi 2019)*

61. Compare the power used in 2 Ω resistor in each of the following circuits.



(AI 2019)

62. A bulb is rated 40 W; 220 V. Find the current drawn by it, when it is connected to a 220 V supply. Also find its resistance. If the given bulb is replaced by a bulb of rating 25 W; 220 V, will there be any change in the value of current and resistance? Justify your answer and determine the change. *(AI 2019)*

63. (a) How two resistors, with resistances R_1 Ω and R_2 Ω respectively are to be connected to a battery of emf V volts so that the electrical power consumed is minimum?
(b) In a house 3 bulbs of 100 watt each lighted for 5 hours daily, 2 fans of 50 watt each used for 10 hours daily and an electric heater of 1.00 kW is used for half an hour daily. Calculate the total energy consumed in a month of 31 days and its cost at the rate of ₹ 3.60 per kWh. *(Board Term I, 2017)*

64. (a) An electric bulb is connected to a 220 V generator. If the current drawn by the bulb is 0.50 A, find its power.
(b) An electric refrigerator rated 400 W operates 8 hours a day. Calculate the energy per day in kWh.
(c) State the difference between kilowatt and kilowatt hour. *(3/5, Board Term I, 2013)*

65. (i) State one difference between kilowatt and kilowatt hour. Express 1 kWh in joules.
(ii) A bulb is rated 5V; 500 mA. Calculate the rated power and resistance of the bulb when it glows. *(Board Term I, 2013)*

Detailed Solutions

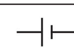
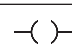
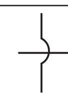
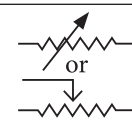
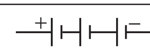
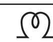
1. Given that : $I = 10$ A, $t = 2$ min $= 2 \times 60$ s $= 120$ s
(i) Amount of charge Q passed through any area of cross-section is given by $I = \frac{Q}{t}$
or $Q = I \times t$ ∴ $Q = (10 \times 120)$ A s $= 1200$ C
(ii) Since, $Q = ne$
where n is the total number of electrons flowing and e is the charge on one electron
∴ $1200 = n \times 1.6 \times 10^{-19}$
or $n = \frac{1200}{1.6 \times 10^{-19}} = 7.5 \times 10^{21}$

2. Electric current is the amount of charge flowing through a particular area in unit time.

3. One ampere is constituted by the flow of one coulomb of charge per second.
$1 \text{ A} = 1 \text{ C s}^{-1}$

4. A cell or a battery can be used to maintain a potential difference between the ends of a conductor. The chemical reaction within a cell generates the potential difference across the terminals of the cell, even when no current is drawn from it. When it is connected to a conductor, it produces electric current and maintain the potential difference across the ends of the conductor.

5.

S. No.	Component	Symbol
(i)	An electric cell	
(ii)	Open plug key	
(iii)	Wires crossing without connection	
(iv)	Variable resistor	
(v)	Battery	
(vi)	Electric bulb	
(vii)	Resistance	

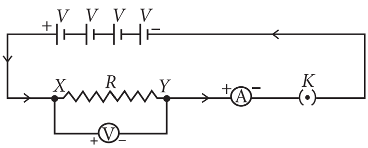
6. **(d)** : The inverse of the slope of I-V graph gives the resistance of the material. Here the slope of R_3 is highest. Thus, $R_2 > R_1 > R_3$.

7. It states that the potential difference V, across the ends of a given metallic wire in an electric circuit is directly proportional to the current flowing through it, provided its temperature remains the same. Mathematically,

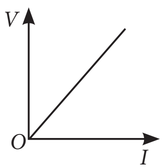
$$V \propto I$$
$$V = RI$$

where R is resistance of the conductor.

8. As graph is a straight line, so it is clear from the graph that $V \propto I$.



The shape of the graph obtained by plotting potential difference applied across conductor against the current flowing through it will be a straight line.



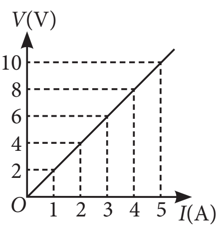
According to ohm's law,

$V = IR$ or $R = \frac{V}{I}$

So, the slope of V-I graph at any point represents the resistance of the given conductor.

9. Since, the graph is straight line so we can either extrapolate the data or simply mark the value from graph as shown in figure.

Current, I(A)	Voltage, V(V)
0	0
1	2
2	4
3	6
4	8



Hence, the value of current for V = 10 volts is 5 amperes (or 5 A).

From Ohm's law, $V = IR$,

We can write, $R = \frac{V}{I}$

At any point on the graph, resistance is the ratio of values of V and I. Since, the given graph is straight line (ohmic conductor) so, the slope of graph will also give the resistance of the resistor

$$R = \frac{10\ \text{V}}{5\ \text{A}} = 2\ \Omega$$

Alternately, $R = \frac{(8-2)\ \text{V}}{(4-1)\ \text{A}} = \frac{6\ \text{V}}{3\ \text{A}} = 2\ \Omega$

10. (i) *Refer to answer 8.*

(ii) *Refer to answer 7.*

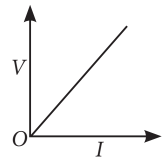
11. *Refer to answer 7 and 8.*

12. Ohm's law : *Refer to answer 7.*

Resistance : It is the property of a conductor to resist the flow of charges through it.

Its SI unit is ohm (Ω). If the potential difference across the two ends of a conductor is 1 V and the current through it is 1 A, then the resistance R, of the conductor is 1 ohm (1 Ω).

$$1\,\text{ohm} = \frac{1\,\text{volt}}{1\,\text{ampere}}$$



V-I graph for an ohmic conductor can be drawn as given in figure.

Important feature of V-I graph are:

(i) It is a straight line passing through origin.

(ii) Slope of V-I graph gives the value of resistance of conductor slope $= R = \frac{V}{I}$

13. **(c)** : Metals and alloys are good conductors of electricity. Bronze is an alloy of copper and tin which are metals and thus is a good conductor of electricity.

14. **(c)** : The resistance of a conductor of length l, and area of cross section, A is

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

where ρ is the resistivity of the material.

Now for the conductor of length $2l$, area of cross-section A' and resistivity ρ.

$$R' = \rho\frac{l'}{A'} = \rho\frac{2l}{A'}$$

But given, $R = R' \Rightarrow \rho\frac{l}{A} = \rho\frac{2l}{A'}$ or $A' = 2A$

15. **(a)**

16. The resistivity of an alloy is generally higher than that of its constituent metals.

17. (i) Resistance of a conductor depends upon the following factors:

(1) Length of the conductor : Greater the length (l) of the conductor more will be the resistance (R).

$$R \propto l$$

(2) Area of cross-section of the conductor: Greater the cross-sectional area of the conductor, less will be the resistance.

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

(3) Nature of conductor.

(ii) SI unit of resistivity is Ω m.

18. For the given metal wire,

length, l = 2 m

area of cross-section, $A = 1.55 \times 10^{-6}\ \text{m}^2$

resistivity of the metal, $\rho = 2.8 \times 10^{-8}\ \Omega\ \text{m}$

Since, resistance, $R = \rho\dfrac{l}{A}$

So, $R = \left(\dfrac{2.8\times10^{-8}\times2}{1.55\times10^{-6}}\right)\Omega$

$= \dfrac{5.6}{1.55}\times10^{-2}\,\Omega = 3.6\times10^{-2}\,\Omega$ or $R = 0.036\ \Omega$

19. (a) *Refer to answer 17 (i).*
(b) Metal have very low resistivity and hence they are good conductors of electricity.
Whereas glass has very high resistivity so glass is a bad conductor of electricity.
(c) Alloys are commonly used in electrical heating devices due to the following reasons
(i) Alloys have higher resistivity than metals
(ii) Alloys do not get oxidised or burn readily.

20. We are given, the length of wire, $l = 1$ m, radius of wire, $r = 0.01$ cm $= 1\times10^{-4}$ m and resistance, $R = 20\ \Omega$
As we know,
$R = \rho\dfrac{l}{A}$, where ρ is resistivity of the material of the wire.

$\therefore\quad 20\ \Omega = \rho\dfrac{l}{\pi r^2} = \rho\dfrac{1\text{ m}}{3.14\times(10^{-4})^2\text{ m}^2}$

$\therefore\quad \rho = 6.28\times10^{-7}\,\Omega$ m

21. Given; resistivity of copper $= 1.6\times10^{-8}\ \Omega$ m, diameter of wire, $d = 0.5$ mm and resistance of wire, $R = 100\ \Omega$

Radius of wire, $r = \dfrac{d}{2} = \dfrac{0.5}{2}$ mm

$= 0.25$ mm $= 2.5\times10^{-4}$ m

Area of cross-section of wire, $A = \pi r^2$

$\therefore\quad A = 3.14\times(2.5\times10^{-4})^2$

$\simeq 1.9625\times10^{-7}\text{ m}^2$

$\simeq 1.9\times10^{-7}\text{ m}^2$

As, $R = \rho\dfrac{l}{A}$

$\therefore\quad 100\ \Omega = \dfrac{1.6\times10^{-8}\,\Omega\text{ m}\times l}{1.9\times10^{-7}\text{ m}^2}$

$l \approx 1200$ m

If diameter is doubled ($d' = 2d$), then the area of cross-section of wire will become

$A' = \pi r^2 = \pi\left(\dfrac{d'}{2}\right)^2 = \pi\left(\dfrac{2d}{2}\right)^2 = 4A$

Now $R \propto \dfrac{1}{A}$, so the resistance will decrease by four times or new resistance will be

$R' = \dfrac{R}{4} = \dfrac{100}{4} = 25\ \Omega$

22. Here, $r = 0.01$ cm $= 10^{-4}$ m, $\rho = 50\times10^{-8}\Omega$ m and $R = 10\ \Omega$

As, $R = \rho\dfrac{l}{A}$

or $\quad l = \dfrac{RA}{\rho} = \dfrac{R}{\rho}(\pi r^2) \qquad (\because\ A = \pi r^2)$

So, $l = \dfrac{10}{50\times10^{-8}}3.14\times\left(10^{-4}\right)^2$

$= 0.628$ m $= 62.8$ cm

23. When wire is melted, its volume remains same, so,

$V' = V \quad$ or $A'l' = Al$

Here, $l' = \dfrac{l}{2}$

Therefore, $A' = 2A$

Resistance, $R = \rho\dfrac{l}{A} = 16\ \Omega$

Now, $R' = \rho\dfrac{l'}{A'} = \rho\dfrac{(l/2)}{2A} = \dfrac{1}{4}\rho\dfrac{l}{A}$

So, $R' = \dfrac{R}{4} = \dfrac{16}{4} = 4\ \Omega \qquad (\because\ R = 16\ \Omega)$

Percentage change in resistance,

$= \left(\dfrac{R-R'}{R}\right)\times100 = \left(\dfrac{16-4}{16}\right)\times100 = 75\%$

24. If the radius of conductor is halved, the area of cross-section reduced to $\left(\dfrac{1}{4}\right)^{\text{th}}$ of its previous value.

Since, $R \propto \dfrac{1}{A}$, resistance will become four times

From Ohm's law, $V = IR$

For given V, $I \propto \dfrac{1}{R}$

So, current will reduce to one-fourth of its previous value.

25. Resistance is the property of a conductor to resist the flow of charges through it.
Factors affecting resistance of a conductor:
Refer to answer 17(i)
Rheostat is the device which is often used to change the resistance without changing the voltage source in an electric circuit.
We are given, length of wire, $l = 50$ cm $= 50\times10^{-2}$m
cross-sectional area, $A = 0.01\text{ mm}^2$

$= 0.01 \times 10^{-6} m^2$
and resistivity, $\rho = 5 \times 10^{-8}\ \Omega$ m.

As, resistance, $R = \rho \dfrac{l}{A}$

$$\therefore \quad R = \left(\frac{5\times10^{-8}\times50\times10^{-2}}{0.01\times10^{-6}}\right)\Omega$$

$= 2.5\ \Omega$

26. (a) : The maximum resistance can be obtained from a group of resistors by connecting them in series. Thus,

$$R_s = \frac{1}{5}+\frac{1}{5}+\frac{1}{5}+\frac{1}{5}+\frac{1}{5} = 1\ \Omega$$

27. (c) : A group of resistors can produce maximum resistance when they all are connected in series.

$\therefore \quad R_s = 2\ \Omega + 2\ \Omega + 2\ \Omega + 2\ \Omega = 8\ \Omega$

28. (a) : The maximum resistance can be produced from a group of resistors by connecting them in series.

Thus, $R_s = \frac{1}{2}\Omega + \frac{1}{2}\Omega + \frac{1}{2}\Omega + \frac{1}{2}\Omega = 2\ \Omega$

29. Here, $R_1 = 10\ \Omega$, $R_2 = 15\ \Omega$, $R_3 = 5\ \Omega$.
In parallel combination, equivalent resistance, (R_{eq}) is given by

$$\frac{1}{R_{eq}} = \frac{1}{R_1}+\frac{1}{R_2}+\frac{1}{R_3}$$

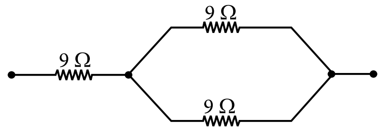
So, $$\frac{1}{R_{eq}} = \frac{1}{10}+\frac{1}{15}+\frac{1}{5}$$

$$\frac{1}{R_{eq}} = \frac{3+2+6}{30} = \frac{11}{30}$$

$$\therefore \quad R_{eq} = \frac{30}{11}\Omega = 2.73\ \Omega$$

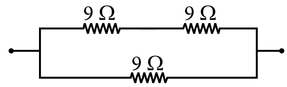
30. (a) When a number of electrical devices are connected in parallel, each device gets the same potential difference as provided by the battery and it keeps on working even if other devices fail. This is not so in case the devices are connected in series because when one device fails, the circuit is broken and all devices stop working.
(b) Parallel circuit is helpful when each device has different resistance and requires different current for its operation as in this case the current divides itself through different devices. This is not so in series circuit where same current flows through all the devices, irrespective of their resistances.

31. (i) The resistance of the series combination is higher than each of the resistances. A parallel combination of two 9 Ω resistors is equivalent to 4.5 Ω. We can obtain 13.5 Ω by coupling 4.5 Ω and 9 Ω in series. So, to obtain 13.5 Ω, the combination is as shown in figure (a).



(a)

(ii) To obtain a equivalent resistance of 6 Ω, we have to connect two 9 Ω resistors in series and then connect the third 9 Ω resistor in parallel to the series combination as shown in the figure (b).



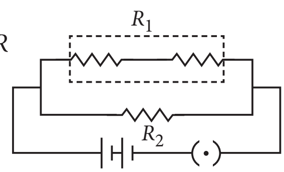
(b)

32. As given in circuit diagram, two 3 Ω resistors are connected in series to form R_1, so
$R_1 = 3\ \Omega + 3\ \Omega = 6\ \Omega$
And, R_1 and R_2 are in parallel combination,
Hence, equivalent resistance of circuit (R_{eq}) is given by

$$\frac{1}{R_{eq}} = \frac{1}{R_1}+\frac{1}{R_2}$$

$$\therefore \quad \frac{1}{R_{eq}} = \frac{1}{6}+\frac{1}{3} = \frac{1+2}{6} = \frac{3}{6} = \frac{1}{2}$$

or $R_{eq} = 2\ \Omega$
Using Ohm's law, $V = IR$
We get,
$3V = I \times 2\ \Omega$
or $I = \frac{3}{2}A = 1.5$ A



Current drawn from the battery is 1.5 A.

33. Let resistance of each resistor be R.
For series combination,
$R_s = R_1 + R_2$
So, $R_s = R + R = 2R$ $\qquad (\because R_1 = R_2 = R)$
For parallel combination,

$$\frac{1}{R_p} = \frac{1}{R_1}+\frac{1}{R_2} \quad \text{or} \quad R_p = \frac{R_1R_2}{R_1+R_2}$$

So, $$R_p = \frac{R\times R}{R+R} = \frac{R}{2}$$

Required ratio $= \dfrac{R_s}{R_p} = \dfrac{2R}{R/2} = 4:1$

34. (a) Given resistance of wire, $R = 6\ \Omega$
Let l be the length of the wire and A be its area of cross-section. Then

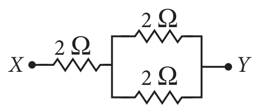
$$R = \frac{\rho l}{A} = 6\ \Omega$$

Now when the length is doubled, $l' = 2l$

and $A' = \frac{A}{2}$ $[\because Al = A'l']$

$$\therefore \quad R' = \frac{\rho(2l)}{A/2} = \frac{4\rho l}{A} = 4 \times 6\ \Omega = 24\ \Omega$$

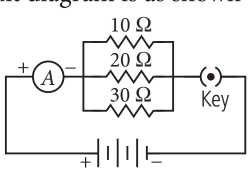
(b) Given the total resistance of the combination $= 3\ \Omega$
In order to get a total resistance of $3\ \Omega$, the three resistors has to be connected as shown.



Such that, $\frac{1}{R_P} = \frac{1}{2} + \frac{1}{2} = 1$

$\Rightarrow \quad R_P = 1\ \Omega$
and $R_S = 2\ \Omega + 1\ \Omega = 3\ \Omega$

35. The circuit diagram is as shown below.



(a) Given, voltage of the battery = 2V + 2V + 2V = 6 V

Current through $10\ \Omega$ resistance,

$$I_{10} = \frac{V}{R} = \frac{6}{10} = 0.6\ \text{A}$$

Current through $20\ \Omega$ resistance,

$$I_{20} = \frac{V}{R} = \frac{6}{20} = 0.3\ \text{A}$$

Current through $30\ \Omega$ resistance,

$$I_{30} = \frac{V}{R} = \frac{6}{30} = 0.2\ \text{A}$$

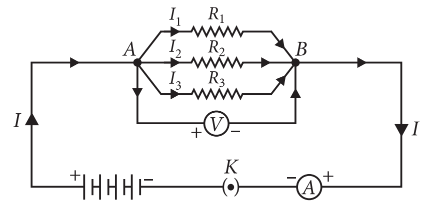
(b) Total current in the circuit, $I = I_{10} + I_{20} + I_{30}$ $= 0.6 + 0.3 + 0.2 = 1.1\ \text{A}$

(c) Total resistance of the circuit,

$$\frac{1}{R_P} = \frac{1}{10} + \frac{1}{20} + \frac{1}{30} = \frac{11}{60}$$

$$\therefore \quad R_P = \frac{60}{11}\ \Omega$$

36. (a) Resistors in parallel : When resistors are connected in parallel.



(i) The potential difference across their ends is the same.
(ii) The sum of current through them is the current drawn from the source of energy or cell.

$$I = I_1 + I_2 + I_3 \text{ or } \frac{V}{R_P} = \frac{V}{R_1} + \frac{V}{R_2} + \frac{V}{R_3}$$

(iii) The equivalent resistance is given by,

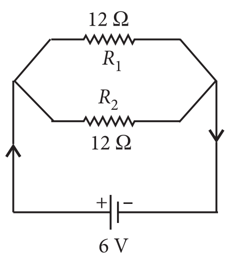
$$\frac{1}{R_P} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

Hence equivalent resistance in parallel combination is equal to the sum of reciprocals of the individual resistances.

(b) $\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2}$

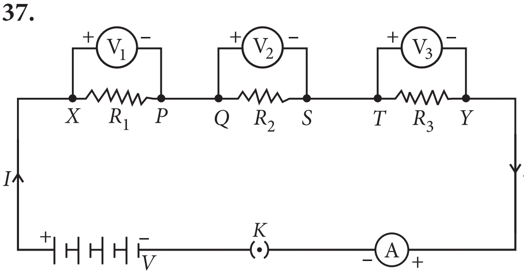
$$\frac{1}{R} = \frac{1}{12} + \frac{1}{12} = \frac{2}{12}$$

$\Rightarrow \quad R = 6\ \Omega$



$\therefore$ Current, $I = \frac{V}{R} = \frac{6}{6} = 1\ \text{A}$

37.



Given figure shows the series combination of three resistors R_1, R_2 and R_3 connected across a voltage source of potential difference V.
Let current I is flowing through the circuit.
V_1, V_2 and V_3 are the potential differences across resistors R_1, R_2 and R_3 respectively.

Since, the total potential difference across a combination of resistors in series is equal to the sum of potential difference across the individual resistors.

$\therefore \quad V = V_1 + V_2 + V_3$ ...(i)

In series current through each resistor is same. Applying the Ohm's law,

$V_1 = IR_1$, $V_2 = IR_2$ and $V_3 = IR_3$ ...(ii)

If R_s is the equivalent resistance of the circuit, then

$V = IR_s$ ...(iii)

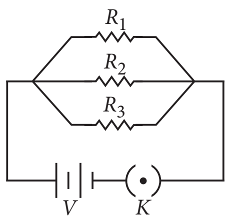
From eqns. (i), (ii) and (iii), we can write

$IR_s = IR_1 + IR_2 + IR_3$

or $R_s = R_1 + R_2 + R_3$

We can conclude that when several resistors are joined in series, the resistance of the combination R_s equals the sum of their individual resistances, R_1, R_2 and R_3.

Given : $R_1 = 6\ \Omega$, $R_2 = 9\ \Omega$, $R_3 = 18\ \Omega$ are connected in parallel.



Equivalent resistance, R_{eq}, is given by

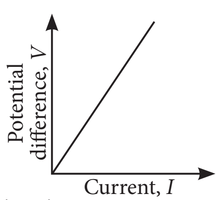
$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

$$\therefore \quad \frac{1}{R_{eq}} = \frac{1}{6} + \frac{1}{9} + \frac{1}{18} = \frac{3+2+1}{18} = \frac{6}{18} = \frac{1}{3}$$

or $R_{eq} = 3\ \Omega$

38. Ohm's law: *Refer to answer 7.*

Graphical representation of Ohm's law



For the given circuit

$R_1 = 3\ \Omega$, $R_2 = 4\ \Omega$, $R_3 = 6\ \Omega$ and $V = 6$ V.

(i) Total effective resistance of the circuit, R_{eq} is given by

$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} = \frac{1}{3} + \frac{1}{4} + \frac{1}{6} = \frac{9}{12}$$

$$\text{or,} \quad R_{eq} = \frac{12}{9}\ \Omega = \frac{4}{3}\ \Omega = 1.33\ \Omega$$

(ii) Since, potential difference across each resistor connected in parallel is same.

So, $V_1 = V_2 = V_3 = 6$ V

Applying Ohm's law,

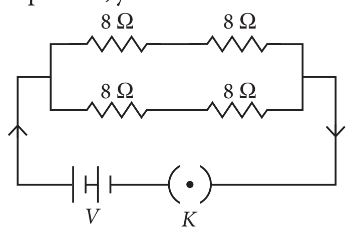
$$V_1 = I_1 R_1 \text{ or } I_1 = \frac{V_1}{R_1} \quad \text{or} \quad I_1 = \frac{6}{3}\ \text{A} = 2\ \text{A}$$

$$\text{Similarly, } I_2 = \frac{6\ \text{A}}{4} = 1.5\ \text{A} \text{ and } I_3 = \frac{6}{6}\ \text{A} = 1\ \text{A}$$

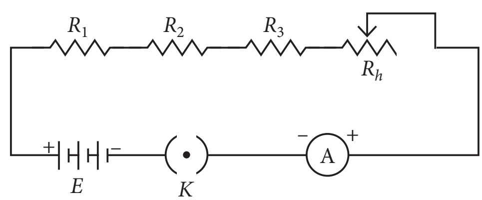
(Note that net current in the circuit is $I = I_1 + I_2 + I_3$)

39. (a) *Refer to answer 37.*

(b) If you have four 8 Ω resistors and the effective resistance is also 8 Ω then the two 8 Ω resistors are connected in series. Now you have pair of two 16 Ω resistors (8 Ω + 8 Ω). If you connect these resistors in parallel, you will have net resistance 8 Ω.



40.



Change the positions of ammeter and note the reading of ammeter each time. You will find that all the reading obtained are same.

So, the value of the current in the ammeter is the same, independent of its position in the electric circuit. It means that in this circuit (series combination) the current is the same in every part of the circuit.

Precautions:

(i) All the connections are neat and tight.

(ii) Ammeter is connected with the proper polarity, *i.e.*, positive terminal of the ammeter should go to positive terminal and negative terminal of ammeter to the negative terminal of the battery or cell used.

41. Let l_A, a_A and R_A be the length, area of cross-section and resistance of wire A and l_B, a_B and R_B are that of wire B.

Here, $l_A = l_B$ and $R_A = R_B$

If ρ_A and ρ_B are the resistivities of wire A and B respectively then

$$R_A = \rho_A \frac{l_A}{a_A} \text{ and } R_B = \rho_B \frac{l_B}{a_B}, \text{ As } R_A = R_B$$

$$\therefore \quad \rho_A \frac{l_A}{a_A} = \rho_B \frac{l_B}{a_B}$$

or $\frac{\rho_A}{\rho_B} = \frac{a_A}{a_B}$ $(\because l_A = l_B)$

Since $\rho_A > \rho_B$ therefore $a_A > a_B$

Hence, wire A is thicker than wire B.

For parallel combination,

$V_1 = V_2 = V_3 = 6$ V

(i) Using Ohm's law

$I_1 = V_1/R_1 = 6/30 = 0.2$ A

$I_2 = V_2/R_2 = 6/10 = 0.6$ A

$I_3 = V_3/R_3 = 6/5 = 1.2$ A

(ii) Total current drawn from battery,

$I = I_1 + I_2 + I_3 = 0.2 + 0.6 + 1.2 = 2$ A

(iii) Equivalent resistance of the circuit, R_{eq} can be obtained by Ohm's law

$V = I R_{eq}$

So, 6 V = 2 A × R_{eq} or, $R_{eq} = \frac{6}{2} = 3\ \Omega$

Aliter, $\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$

$= \frac{1}{30} + \frac{1}{10} + \frac{1}{5} = \frac{1+3+6}{30} = \frac{10}{30} = \frac{1}{3}$

or $R_{eq} = 3\ \Omega$

42. (a) *Refer to answer 37.*

(b) For the given circuit,

$R_1 = 6\ \Omega$, $R_2 = 10\ \Omega$, $R_3 = 15\ \Omega$

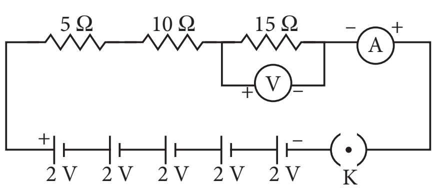
As $\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$

$\frac{1}{R_{eq}} = \frac{1}{6} + \frac{1}{10} + \frac{1}{15}$

$= \frac{5+3+2}{30} = \frac{10}{30} = \frac{1}{3}$

$R_{eq} = 3\ \Omega$

43.



Potential of the battery, $V = (2 \times 5)$ V = 10 V

Equivalent resistance,

$R_{eq} = R_1 + R_2 + R_3$

$= (5 + 10 + 15)\Omega = 30\ \Omega$

(i) Current through circuit, $I = \frac{V}{R} = \frac{10}{30}\text{A} = \frac{1}{3}\text{A}$

(ii) Potential across 5 Ω resistor, $V_1 = IR_1$

$= \frac{1}{3} \times 5 = \frac{5}{3}\text{ V} = 1.67$ V

44. (a) : We know, $H = I^2Rt = \frac{V^2}{R}\cdot t$

Now when, $R' = \frac{R}{2}$, $V' = V$ and $t' = t$

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

45. (a) The Joule's law of heating implies that heat produced in a resistor is

(i) directly proportional to the square of current for a given resistance,

(ii) directly proportional to resistance for a given current, and

(iii) directly proportional to the time for which the current flows through the resistor.

i.e., $H = I^2 Rt$

(b) Given, charge $q = 96000$ C, time $t = 2\text{ h} = 7200$ s and potential difference $V = 40$ V

We know, $H = I^2Rt = \frac{Q^2}{t^2} \times \frac{V}{Q} \times t \times t = VQ$

$= 40 \times 96000 = 3.84 \times 10^6$ J = 3.84 MJ

46. *Refer to answer 45(a).*

47. Electric fuse protects circuits and appliances by stopping the flow of any unduly high electric current. It consists of a piece of wire made of a metal or an alloy of appropriate melting point, for example aluminium, copper, iron, lead etc. If a current larger than the specified value flows through the circuit, the temperature of the fuse wire increases. This melts the fuse wire and breaks the circuit.

48. (a) (i) Tungsten is a strong metal and has high melting point (3380°C).

(ii) It emits light at high temperatures (about 2500°C).

(b) Electric laundry iron and electric heater are based on heating effect of electric current.

49. Let the resistance of the wire be R, heat produced in the fuse at 5 A in 1s is

$H = (5)^2R$ $(\because H = I^2Rt)$

So, fuse melts at $(5)^2R$ joules of heat.

Let, the resistance of new wire is R'

So, heat produced in 1 second = $(10)^2R'$

To prevent it from melting

$(5)^2R = (10)^2R'$ or $R' = \frac{R}{4}$

As $R \propto \frac{1}{A}$

$\therefore$ cross-sectional area of new fuse wire is four times the first fuse.

Now, $A = \pi r^2$, so new radius is twice the previous one. So, at 10A, the new fuse wire of same material and length has larger radius than the earlier one.

50. If only resistors are connected to the battery, the source energy continually gets dissipated entirely in the form of heat. This is known as heating effect of current. The amount of heat (H) produced in time t is given by Joule's law of heating.

$$H = I^2Rt$$

Where, I is current flowing through resistor R.

The electric laundry iron, electric toaster, electric oven, electric kettle and electric heater are some common devices based on heating effect of current.

51. (d) : Given power of first bulb, $P_1 = 100$ W and second bulb $P_2 = 40$ W

Current through 100 W bulb, $I_1 = 1$ A

Current through 40 W bulb, $I_2 = ?$

Since both the bulbs are connected in series, the electric current passing through both the bulbs are same *i.e.*, $I_2 = 1$ A.

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

53. Here, power of lamp, $P = 60$ W

time, $t = 1$s

So, energy consumed

= Power × time = (60× 1)J = 60 J

54. Since both the bulbs are connected in parallel and to a 220 V supply, the voltage across each bulb is 220 V. Then

Current drawn by 100 W bulb,

$$I_1 = \frac{\text{Power rating}}{\text{Voltage applied}} = \frac{100\,\text{W}}{220\text{V}} = 0.454\,\text{A}$$

Current drawn by 60 W bulb,

$$I_2 = \frac{60\,\text{W}}{220\text{V}} = 0.273\,\text{A}$$

Total current drawn from the supply line,

$I = I_1 + I_2 = 0.454\text{ A} + 0.273\text{ A} = 0.727\text{ A} = 0.73\text{ A}$

55. Here, $V = 220$ V, $R = 55\ \Omega$

By Ohm's law $V = IR$

$\therefore$ $220 = I \times 55$ or $I = 4$ A

Wattage of electric iron = Power

$$= \frac{V^2}{R} = \frac{(220)^2}{55} = 880\,\text{W}$$

56. Here, $P = 750$ W, $V = 200$ V

(i) As $P = VI$

$I = P/V = (750/200)$ A = 3.75A

(ii) By Ohm's law $V = IR$ or $R = V/I$

$\therefore$ $R = \frac{200}{3.75}\Omega = 53.3\ \Omega$

(iii) Energy consumed by the iron in 2 hours

$= P \times t = 750\text{ W} \times 2\text{h} = 1.5\text{ kWh}$

or $E = (750 \times 2 \times 3600)\text{ J} = 5.4 \times 10^6\text{ J}$

57. Here, $V = 220$ V, $I = 2.5$ A

Power of the bulb $P = VI = 220 \times 2.5\text{ W} = 550\text{ W}$

58. (a) Power is defined as the rate at which electric energy is dissipated or consumed in an electric circuit.

$P = VI = I^2R = V^2/R$

The SI unit of electric power is watt (W). It is the power consumed by a device that carries 1 A of current when operated at a potential difference of 1 V.

1 W = 1 volt × 1 ampere = 1 V A

(b) Given, $V = 5$ V and $I = 500$ mA = 0.5 A

(i) Power, $P = V \times I = 5 \times 0.5 = 2.5$ W

(ii) As, $P = \frac{V^2}{R} \Rightarrow R = \frac{V^2}{P} = \frac{25}{2.5} = 10\ \Omega$

(iii) Given, time $t = 2.5$ hrs = 9000 s

$\therefore$ The energy consumed, $E = P \times t$

$= 2.5 \times 9000 = 2.25 \times 10^4$ J

= 6.25 Watt hour

59. Given, $R_1 = R_2 = 15\ \Omega$, $V = 6$ V

(i) When connected in series,

$R_s = R_1 + R_2 = 15\ \Omega + 15\ \Omega = 30\ \Omega$

Power, $P_S = \frac{V^2}{R_S} = \frac{36}{30}$ W

(ii) When connected in parallel,

$$\frac{1}{R_P} = \frac{1}{R_1} + \frac{1}{R_2} \Rightarrow R_P = \frac{15}{2}\ \Omega$$

$\therefore$ Power, $P_P = \frac{V^2}{R_P} = \frac{36}{15} \times 2$ W

$\therefore$ The ratio, $\frac{P_S}{P_P} = \frac{36}{30} \times \frac{15}{36 \times 2} = \frac{1}{4}$

60. Resistance of the lamp = 20 Ω
External resistance = 4 Ω
(a) As both the lamp and external resistance are connected in series, therefore the total resistance,

$R = 20 + 4 = 24\ \Omega$

(b) Current, $I = \frac{V}{R} = \frac{6}{24} = 0.25\ \text{A}$

(c) (i) Potential difference across the electric lamp

$$= \frac{\text{Total voltage}}{\text{Total resistance}} \times \text{Resistance of lamp}$$

$$= \frac{6}{24} \times 20 = 5\ \text{V}$$

(ii) Potential difference across conductor

$$= \frac{\text{Total voltage}}{\text{Total resistance}} \times \text{Resistance of conductor}$$

$$= \frac{6}{24} \times 4 = 1\text{V}$$

(d) Power of the lamp
= $(\text{current})^2 \times$ resistance of lamp
= $(0.25)^2 \times 20 = 1.25$ W

61. In circuit *A*,
Total resistance, $R = 1 + 2 = 3\ \Omega$

Voltage across 2 Ω = $\frac{V_{\text{Total}}}{R_{\text{Total}}} \times 2\ \Omega = \frac{6}{3} \times 2 = 4\ \text{V}$

∴ Power used in 2 Ω resistor,

$$P = \frac{V^2}{R} = \frac{(4)^2}{2} = 8\ \text{W}$$

In circuit *B*, Voltage across both the resistance is same *i.e.* 4 V and both are connected in parallel combination.

∴ Power used in 2 Ω resistor = $\frac{V^2}{R} = \frac{(4)^2}{2} = 8$ W

∴ Power used in 2 Ω resistor in each case is same *i.e.* 8 W.

62. In first case, $P = 40$ W, $V = 220$ V

Current drawn, $I = \frac{P}{V} = \frac{40}{220} = 0.18\ \text{A}$

Also, resistance of bulb,

$$R = \frac{V^2}{P} = \frac{(220)^2}{40} = 1210\ \Omega$$

In second case, $P = 25$ W, $V = 220$ V

Current drawn, $I = \frac{P}{V} = \frac{25}{220} = 0.11\ \text{A}$

Also, resistance of the bulb,

$$R = \frac{V^2}{P} = \frac{(220)^2}{25} = 1936\ \Omega$$

Hence, by replacing 40 W bulb to 25 W bulb, having same source of voltage the amount of current flows decreases while resistance increases.

63. (a) Power consumed is minimum when current through the circuit is minimum, so the two resistors are connected in series.
(b) Power of each bulb P_1 = 100 watt
Total power of 3 bulbs, $P_1 = 3 \times 100 = 300$ watt
Energy consumed by bulbs in 1 day
$E_1 = P_1 \times t = 300$ watt × 5 hours.
= 1500 Wh = 1.5 kWh
Power of each fan = 50 watt
Total power of 2 fans = 2 × 50 watt
P_2 = 100 watt
Energy consumed by fans in 1 day
$E_2 = P_2 \times t = 100$ watt × 10 hours
= 1000 watt hour = 1 kWh
Energy consumed by heater,
E_3 = 1 kW × 1/2 h = 0.5 kWh
Total energy consumed in one day
$E = E_1 + E_2 + E_3 = (1.5 + 1 + 0.5)$ kWh = 3 kWh
Total energy consumed in a month of 31 days
= $E \times 31 = (3 \times 31)$ kWh = 93 kWh
Cost of energy consumed = ₹(93 × 3.60) = ₹334.80

64. (a) Here, $V = 220$ V, $I = 0.50$ A
Power of the bulb, $P = VI = (220 \times 0.5)$W = 110 W
(b) Energy consumed by electric refrigerator in a day = Power × time
= 400 W × 8 h = 3200 Wh = 3.2 kWh
(c) Kilowatt is unit of power and kilowatt hour is a unit of energy.

65. (i) *Refer to answer 64(c).*
1 kWh = 1000 W × 1 h
= 1000 W × 3600 s = 3600000 J = 3.6×10^6 J
(ii) Here, $V = 5$ V, $I = 500$ mA = 0.5 A
Power rating of bulb is
$P = VI = (5 \times 0.5)$W = 2.5 W
Resistance of the bulb is $R = V/I = (5/0.5)\ \Omega = 10\ \Omega$