Electricity

TOPICS COVERED

Electric Current and Circuit

Multiple Choice Questions 1 Mark

1. The electric current in the conductor exists only when the quantity that flows through it is
(*a*) electric charge (*b*) air current
(*c*) water current (*d*) all of these

2. Amount of charge flowing through a particular area in unit time is called
(*a*) electric charge (*b*) electric current
(*c*) electric potential (*d*) all of these

3. The unit of electric charge is
(*a*) ampere (*b*) joule
(*c*) coulomb (*d*) ohm

4. Choose the incorrect statements from the following:
(*a*) Charge on the body may be positive or negative.
(*b*) Electric charge is scalar quantity.
(*c*) Coulomb is the cgs unit of charge.
(*d*) A continuous and closed path is required for the flow of electric charge.

5. The particles that constitute the flow of charge through a conductor is
(*a*) electrons (*b*) protons
(*c*) neutrons (*d*) atoms

6. The materials which allow electric current to pass through them easily are called
(*a*) conductors (*b*) insulators
(*c*) semiconductors (*d*) alloys

7. Conventionally, direction of electric current in the circuit is taken as the direction of flow of
(*a*) negative charge (*b*) atoms
(*c*) positive charge (*d*) neutrons

8. The relation between electric current and electric charge is
(*a*) $Q = I/t$ (*b*) $t = QI$
(*c*) $I = Qt$ (*d*) $I = Q/t$

9. The number of electrons constituting one coulomb of charge is
(*a*) 6×10^{18} (*b*) 1.6×10^{-19}
(*c*) 6×10^{-18} (*d*) 1.6×10^{19}

10. SI unit of electric current is
(*a*) ohm (*b*) ampere (*c*) volt (*d*) joule

11. The value of 1 mA and 1 μA are [CBSE 2020]
(*a*) 10^{-6} and 10^{-3} A respectively
(*b*) 10^{-6} and 10^{-9} A respectively
(*c*) 10^{-3} and 10^{-6} A respectively
(*d*) 10^{3} and 10^{6} A respectively

Ans. (*c*)

Answers

1. (*a*)	2. (*b*)	3. (*c*)	4. (*c*)
5. (*a*)	6. (*a*)	7. (*c*)	8. (*d*)
9. (*a*)	10. (*b*)	11. (*c*)	

VSA Very Short Answer Type Questions 2 Marks

12. State two properties of charge.

Ans. Properties of Charge

(*i*) The basic idea about positive and negative charge is that "like charges repel and unlike charges attract each other.

(*ii*) Electric charge can neither be created nor destroyed but it can transfer from one body to another i.e., total electric charge in an isolated system is conserved.

(*iii*) Total charge on a body is equal to the algebraic sum of all the charges located on that body.

(*iv*) Charges are quantized i.e., charge on a body is an integral multiple of the charge of electron or proton.

Therefore, the total charge Q on a body is given by

$$Q = ne$$

Where, $e = 1.6 \times 10^{-19}$ coulomb, $n = \pm 1, \pm 2, \pm 3$, and so on. (*any two*)

13. Name the two fundamental particles which carry equal and opposite charges. What amount of charge they carry?

Ans. Electron and proton

Charge on electron $= -1.6 \times 10^{-19}$ C

Charge on proton $= +1.6 \times 10^{-19}$ C

14. How many electrons must be removed from a conductor, so that it acquires a charge of 4.8 μC?

Ans. Here $q = 4.8\ \mu C = 4.8 \times 10^{-6}$ C

Charge on electron, $e = 1.6 \times 10^{-19}$ C

Using, $q = ne$

$$\Rightarrow \quad n = \frac{q}{e} = \frac{4.8 \times 10^{-6}}{1.6 \times 10^{-19}} = 3 \times 10^{13}$$

So, $n = 3 \times 10^{13}$ electrons

15. In how much time 9×10^3 coulomb of charge will flow, if an electric current of 6 A is drawn by an electrical appliance?

Ans. Using, $Q = It \Rightarrow 9 \times 10^3 = 6 \times t$

$\therefore \quad t = \dfrac{9 \times 10^3}{6} = 1500 \text{ s} = 25 \text{ min}$

SA Short Answer Type Question 3 Marks

16. A current of 1 A is drawn by a filament of an electric bulb. Calculate the number of electrons passing through the cross-section of the filament in 30 minutes.

Ans. Given: $I = 1$ A, $t = 30$ min $= 30 \times 60 = 1800$ sec

Using, $Q = It = 1 \times 1800 = 1800$ C

Now, $Q = ne$

$\Rightarrow \quad 1800 = n \times 1.6 \times 10^{-19}$

$\Rightarrow \quad n = \dfrac{1800}{1.6 \times 10^{-19}} = 1125 \times 10^{19}$

$\Rightarrow \quad n = 1.125 \times 10^{22}$

Hence, number of electrons passing through the filament in 30 minutes $= 1.125 \times 10^{22}$ electrons.

$\simeq 10^{22}$ electrons

LA Long Answer Type Question 5 Marks

17. What is meant by electric current? Name and define its SI unit. In a conductor electrons are flowing from B to A. What is the direction of conventional current? Give justification for your answer. A steady current of 1 ampere flows through a conductor. Calculate the number of electrons that flows through any section of the conductor in 1 second. (Charge on electron 1.6×10^{-19} coulomb).

[CBSE 2015]

Ans.

- **Electric Current:** The amount of charge 'Q' flowing through a particular area of cross section in unit time 't' is called electric current. i.e.

  Electric current, $I = \dfrac{Q}{t}$
- SI unit of electric current is ampere.
- **One ampere** of current is that current which flow when one coulomb of electric charge flowing through a particular area of cross-section of the conductor in one second, i.e. $1\text{A} = 1\ \text{Cs}^{-1}$.
- **The direction** of conventional current is A to B, i.e. opposite to the direction of flow of electrons. In a metal, flow of electrons carrying negative charge constitutes the current. Direction of flow of electrons gives the direction of electronic current by convention, the direction of flow of positive charge is taken as the direction of conventional current.
- Charge, $q = It = ne$

$$n = \frac{It}{e} = \frac{1 \times 1}{1.6 \times 10^{-19}\, C} = \frac{10^{19}}{1.6}$$

$= 6.25 \times 10^{18}$ electrons

PRACTICE QUESTIONS

1. The device which measures the electric current in the circuit is
   (*a*) ammeter (*b*) voltmeter
   (*c*) galvanometer (*d*) all of these
2. If electrons flow in a conductor from its one end 'A' to other end 'B', the current will flow from
   (*a*) A to B (*b*) B to A
   (*c*) mid-point of the conductor to end A
   (*d*) mid-point of the conductor to end B
3. Calculate the amount of charge that would flow in one hour through an element of electric gyser drawing a current of 2 A.
4. How long would a charge of 900 C move through a closed circuit at a steady rate of 15 Cs^{-1}?
5. 5.40×10^{21} electrons flow through the element of electric iron in 3 minutes.
   (*a*) How much charge flows through this appliance?
   (*b*) Calculate the current flow through it in 3 min.

TOPICS COVERED

Electric Potential and Potential Difference

Multiple Choice Questions 1 Mark

1. The amount of work done to move a unit charge from one point to the other in an electric circuit carrying some current is called as

(*a*) power
(*b*) electric potential difference
(*c*) electric current
(*d*) resistance

2. Amount of work done needed for each coulomb of charge between two points in a current carrying conductor having potential difference of 1 V is

(*a*) 1 Joule (*b*) 1 Watt
(*c*) 1 Ohm (*d*) 1 kW

3. 1 volt is equal to

(*a*) 1 Js^{-1} (*b*) 1 JC^{-1}
(*c*) 1 Nm^{-1} (*d*) 1 CJ^{-1}

4. The source of energy which provide the potential difference for the steady flow of current in the electric circuit is

(*a*) ammeter (*b*) voltmeter
(*c*) battery (*d*) all of these

5. Potential difference between two points in an electric circuit is measured by an instrument called

(*a*) battery (*b*) ammeter
(*c*) galvanometer (*d*) voltmeter

6. Which of the following expressions correctly represent the potential difference between two points in an electric circuit?

(*a*) $V = \frac{W}{Q}$ (*b*) $V = \frac{Q}{W}$
(*c*) $V = Q \times W$ (*d*) $Q = VW$

7. A battery of 10 volt carries 20,000 C of charge through a resistance of 20 Ω. The work done in 10 seconds is

(*a*) 2×10^3 joule (*b*) 2×10^5 joule
(*c*) 2×10^4 joule (*d*) 2×10^2 joule

8. When two points at different potential are connected across the ends of a conductor, the electric current flows through it from the point

(*a*) at a higher potential to a lower potential
(*b*) at a lower potential to a higher potential
(*c*) at zero potential to the some potential point
(*d*) cannot say

Answers

1. (*b*) **2.** (*a*) **3.** (*b*) **4.** (*c*)
5. (*d*) **6.** (*a*)
7. (*b*) $W = qV = 20000 \times 10 = 2{,}00{,}000 = 2 \times 10^5$ J
8. (*a*)

VSA Very Short Answer Type Questions 2 Marks

9. Why must voltmeter have high resistance?

Ans. The voltmeter connected in parallel across the component, such as resistor must have high resistance so that a very small current passes through it and the potential difference across that component is not affected.

10. When a particle of charge 10 μC is brought from infinity to a point in the electric field, 10 mJ work is done by the external forces. What is the potential at that point?

Ans. Given $Q = 10\ \mu C = 10 \times 10^{-6}\ C = 10^{-5}\ C$
$W = 10\ mJ = 10 \times 10^{-3}\ J = 10^{-2}\ J$
At infinity potential is zero
Using, $V_A - V_B = \frac{W}{Q}$
$\Rightarrow \quad V - V_\infty = \frac{W}{Q}$ (let $V_A = V$, $V_B = V_\infty$)
$\Rightarrow \quad V - 0 = \frac{10^{-2}}{10^{-5}}$
$\Rightarrow \quad V = 10^{-2+5} = 10^3 = 1000$ V

11. (*a*) State the relation between work, charge and potential difference for an electric circuit.
(*b*) Calculate the potential difference between the two terminals of a battery if 100 J of work is required to transfer 20 C of charge from one terminal of the battery to the other.

Ans. (*a*) Potential difference $= \frac{\text{Work done}}{\text{Charge}}$
$V_A - V_B = \frac{W}{Q}$
(*b*) $Q = 20$ C, $W = 100$ J
$\therefore$ Potential difference,
$V = \frac{W}{Q} = \frac{100}{20}$
$\Rightarrow \quad V = 5$ volt

12. Calculate the amount of work done in shifting of charge of 2 C from a point A to B having potentials +10 V and –5 V respectively.

Ans. $Q = 2$ C, $V_A = +10$ V, $V_B = -5$ V
Using $V_A - V_B = \frac{W}{Q}$
$\Rightarrow \quad 10 - (-5) = \frac{W}{2}$
$\Rightarrow \quad W = 30$ J

SA Short Answer Type Question 3 Marks

13. Define 1 volt. Express it in terms of SI unit of work and charge. Calculate the amount of energy consumed in carrying a charge of 1 coulomb through a battery of 3 V. [CBSE 2014]

Ans. When 1 joule of work is done in carrying 1 coulomb of charge, from infinity to a point in the electric field, then potential at that point is called 1 volt.
Potential difference between two points is
$V = \frac{W}{Q}$
or $W = Q \times V$
$= 1 \times 3 = 3$ J

PRACTICE QUESTIONS

1. In an electric circuit, there are two paths available between two points 'A' and 'B' for the transfer of charge 'q'. Let the work done be W_1 and W_2, for path 1 and 2, respectively. Which of the following relationship is true?
   (*a*) $W_1 < W_2$ (*b*) $W_1 = W_2$
   (*c*) $W_1 > W_2$ (*d*) Insufficient data, cannot say
2. A manufacturer has shown that the potential difference between two terminals of the battery is 24 volts.

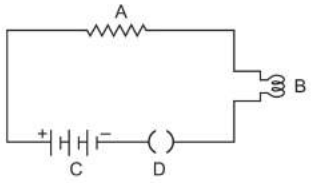
   Four students interpret it as follows:
   (*a*) $V_A = 6$ V and $V_B = -18$ V
   (*b*) $V_A = +10$ V and $V_B = -14$ V
   (*c*) $V_A = 24$ V and $V_B = 0$ V
   (*d*) $V_A - V_B = 24$ V
   Choose the best interpretation from the above.
3. (*a*) What do you understand by the term "electric potential at a point" in an electric field?
   (*b*) Potential difference between two points is measured by voltmeter. How it is connected in the circuit?
4. Calculate the work done in moving of charge of 2 C from a point at 30 V to another point at 50 V.
5. How much chemical energy is transferred by a 24 V battery to each coulomb of charge to move in a circuit?

TOPICS COVERED

Circuit and Circuit Diagram

Multiple Choice Questions 1 Mark

1. **A continuous and closed path of an electric current is called**
   (*a*) an electric circuit
   (*b*) electric pressure
   (*c*) circuit element
   (*d*) all of these
2. **The position of switch/key in an electric circuit is**
   (*a*) right side of the cell or battery
   (*b*) left side of the cell or battery
   (*c*) anywhere in the circuit
   (*d*) before the circuit element
3. **The function of switch in an electric circuit is**
   (*a*) to make the circuit closed
   (*b*) to make the circuit open
   (*c*) both (*a*) and (*b*)
   (*d*) neither (*a*) nor (*b*)
4. **Which of the following is an essential element in an electric circuit?**
   (*a*) Connecting wire (*b*) Bulb
   (*c*) An ammeter (*d*) A plug key
5. **A schematic diagram drawn by using symbols which represent electrical components is called**
   (*a*) electric diagram (*b*) circuit diagram
   (*c*) element diagram (*d*) current diagram
6. **Identify the electrical components labelled as A, B, C and D.**



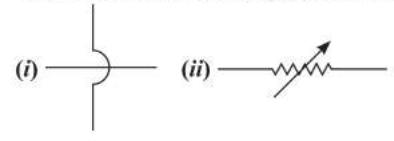
   (*a*) A-Bulb, B-Battery, C-Open key, D-Resistor
   (*b*) A-Resistor, B-Bulb, C-Battery, D-Open key
   (*c*) A-Cell, B-Bulb, C-Resistor, D-Closed key
   (*d*) A-Variable Resistor, B-Bulb, C-Cell, D-Closed key

Answers

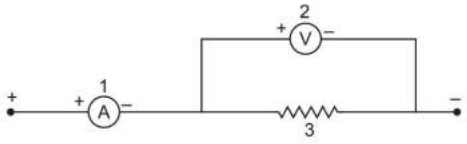
1. (*a*) 2. (*c*) 3. (*c*) 4. (*a*)
5. (*b*) 6. (*b*)

Very Short Answer Type Questions 2 Marks

7. **(*a*) What do the following symbols represent?**



   (*b*) Name the electrical devices that are connected in the following part of the circuit.



Ans. (*a*) (*i*) Wire crossing without joining
(*ii*) Variable resistor or rheostat
(*b*) 1-Ammeter, 2-voltmeter and 3-resistor

8. What is an electric circuit? Distinguish between an open and a closed circuit.

Ans. An arrangement for maintaining the continuous flow of electric current by the electrical energy source through the various electrical components connected with each other by conducting wires is termed as electric circuit.

An open circuit does not carry any current, while a closed circuit carries current.

PRACTICE QUESTIONS

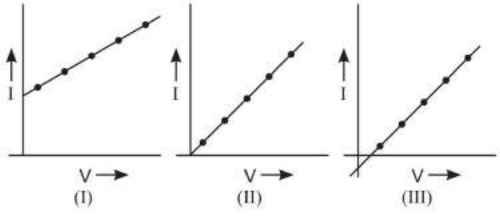
1. The direction of conventional current in electric circuit marked by you in the external circuit is
   (*a*) from negative terminal to positive terminal of the cell
   (*b*) from positive terminal to negative terminal of the cell
   (*c*) in any direction
   (*d*) cannot say
2. (*a*) What is the use of connecting wires in the electric circuit?
   (*b*) What is the role of electric switch/key in the circuit?
3. What are three basic components of a circuit?

TOPICS COVERED

Ohm's Law and Factors on which the Resistance of a Conductor Depends

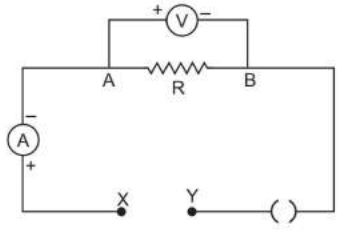
Multiple Choice Questions **1 Mark**

1. **Choose the incorrect statement regarding Ohm's law.**
   (*a*) It is temperature independent
   (*b*) It is valid for constant temperature
   (*c*) It is valid for ohmic resistance
   (*d*) It defines the relationship between potential difference and current through the conductor.
2. **In Ohm's law, if physical condition of the conductor remains same, then**
   (*a*) $I \propto V$ (*b*) $I \propto \frac{1}{V}$
   (*c*) $I \propto V^2$ (*d*) $I \propto \frac{1}{V^2}$
3. **In the experiment on studying the dependence of current (*I*) and potential difference (*V*), three students plotted the following graph between (*V*) and (*I*) as per their respective observations.**

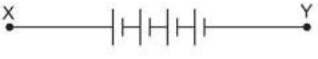


The observation likely to be correct are those of
(*a*) Student I only (*b*) Student II only
(*c*) Student III only (*d*) All the three students

4. **To the terminals marked as X and Y in the given circuit, three students connect 4 cells of voltage 1.5 V each in three different manners shown below.**

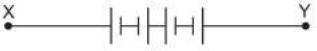


Student (A):



Student (B):

Student (C):

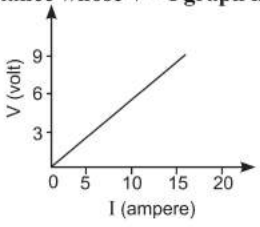


Which of the following student(s) get the maximum reading of voltmeter?

(*a*) Student A (*b*) Student B
(*c*) Student C (*d*) All three students

5. **For verifying Ohm's law, we design an electric circuit diagram in which we show the arrangement of different circuit components. We find that with respect to resistor** [CBSE 2023]
   (*a*) ammeter is connected in parallel and voltmeter in series.
   (*b*) ammeter is connected in series and voltmeter in parallel.
   (*c*) ammeter and voltmeter are both connected in series.
   (*d*) ammeter and voltmeter are both connected in parallel.

6. **The resistance whose V – I graph is given below is**

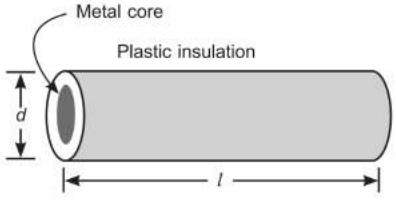


(*a*) $\frac{5}{3}\ \Omega$ (*b*) $\frac{3}{5}\ \Omega$ (*c*) $\frac{5}{2}\ \Omega$ (*d*) $\frac{2}{5}\ \Omega$

7. **When a 4 V battery is connected across an unknown resistor there is a current of 100 mA in the circuit. The value of the resistance of the resistor is** [CBSE 2019]
   (*a*) 4 Ω (*b*) 40 Ω (*c*) 400 Ω (*d*) 0.4 Ω

8. **A cylindrical conductor of length '*l*' and uniform area of cross-section '*A*' has resistance '*R*'. Another conductor of length 2.5*l* and resistance 0.5*R* of the same material has area of cross-section** [CBSE 2020]
   (*a*) 5 A (*b*) 2.5 A (*c*) 0.5 A (*d*) $\frac{1}{5}$ A

9. **The value of specific resistance depends upon**
   (*a*) area of cross-section of the conductor
   (*b*) length of the conductor
   (*c*) nature of material of conductor
   (*d*) all of above

10. 

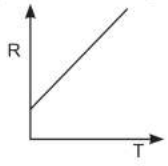
Plastic insulation surrounds a wire having diameter *d* and length *l* as shown above. A decrease in the resistance of the wire would be produced by an increase in the [CBSE Sample Paper 2023]
(*a*) length *l* of the wire (*b*) diameter *d* of the wire
(*c*) temperature of the wire
(*d*) thickness of the plastic insulation

11. **A complete circuit is left on for several minutes, causing the connecting copper wire to become hot. As the temperature of the wire increases, the electrical resistance of the wire** [CBSE Sample Paper 2023]
   (*a*) decreases. (*b*) remains the same.
   (*c*) increases.
   (*d*) increases for some time and then decreases.

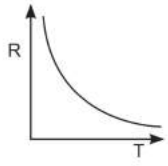
12. **The resistivity of the metals and alloys are in the range of**
   (*a*) $10^{-8}\ \Omega$ m to $10^{-6}\ \Omega$ m
   (*b*) $10^{-10}\ \Omega$ m to $10^{-14}\ \Omega$ m
   (*c*) $10^{10}\ \Omega$ m to $10^{14}\ \Omega$ m
   (*d*) $10^{8}\ \Omega$ m to $10^{6}\ \Omega$ m

13. **The temperature of a conductor is increased. The graph best showing the variation of its resistance is**

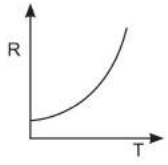
(*a*)



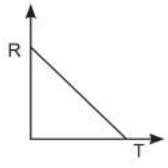
(*b*)



(*c*)



(*d*)



Answers

1. (*a*) 2. (*a*) 3. (*b*) 4. (*a*)
5. (*b*)
6. (*b*) Resistance = slope line of V-I graph
$$= \frac{9-0}{15-0} = \frac{9}{15} = \frac{3}{5}\ \Omega.$$
7. (*b*) Given: $V = 4$ V, $I = 100$ mA $= 0.1$ A
Using, $V = IR$
$$\therefore \quad R = \frac{V}{I} = \frac{4}{0.1} = 40\ \Omega$$
8. (*a*) **Case I:** $R = \rho\frac{l}{A}$
Case II: $0.5R = \rho\frac{2.5l}{A'}$
On dividing, we get,
$A' = 5$ A

9. (*c*)

10. (*b*) diameter (*d*) of the wire

11. (*c*)

12. (*a*)

13. (*a*) Resistance is directly proportional to temperature of the conductor.

VSA Very Short Answer Type Questions 2 Marks

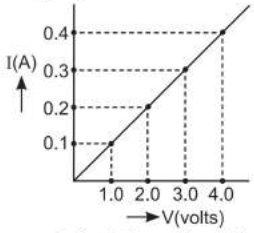
14. **How much current will an electric bulb draw from 220 V source, if the resistance of the bulb is 1200 Ω? If in place of bulb, a heater of resistance 100 Ω is connected to the sources, calculate the current drawn by it.**

Ans. Given : V : 220 V, $R_1 = 1200\ \Omega$, $I_1 = ?$
$R_2 = 100\ \Omega$, $I_2 = ?$
Using Ohm's law, $V = I_1 R_1$

$$\Rightarrow \quad I_1 = \frac{V}{R_1} = \frac{220}{1200} = 0.18\ \text{A}$$

and, $$I_2 = \frac{V}{R_2} = \frac{220}{100} = 2.2\ \text{A}$$

15. **In a experiment to study the dependence of current on potential difference across a resistor, a student obtained the graph as shown in the diagram.**



From the graph find the value of resistance of the given resistor.

Ans. From the I-V graph,

$$\text{Resistance} = \frac{1}{\text{Slope of line}} = \frac{1}{\Delta I/\Delta V}$$

$$= \frac{\Delta V}{\Delta I} = \frac{3-2}{0.3-0.2} = 10\ \Omega$$

16. **100 J of work is done in transferring 20 C of charge between two points in a conductor. Find the resistance offered by the conductor, if a current of 2A flows through it.** [HOTS]

Ans. Given : $W = 100$ J, $q = 20$ C, $I = 2$ A, $R = ?$
Work done in carrying 20 C charge

$$W = qV$$

From Ohm's law, $V = IR$

$$\therefore \quad W = q(IR)$$

$$\Rightarrow \quad R = \frac{W}{qI} = \frac{100}{20 \times 2} = \frac{5}{2} = 2.5\ \Omega$$

17. **Priya has a copper wire and an aluminium wire of the same length. Can the electrical resistance of the two wires be the same? Justify your answer.**

Ans. Yes, the electrical resistance of the two wires can be the same.
The reasons can be:
– The area of cross-section of the two wires is different.
– The thickness of the two wires is different.

18. **A piece of wire of resistance 20 Ω is drawn out so that its length is increased to twice its original length. Calculate the resistance of the wire in the new situation.**

Ans. Using, $$R = \frac{\rho l}{A},$$

We have, $$\frac{R_1}{R_2} = \frac{l_1}{A_1} \cdot \frac{A_2}{l_2}$$

Given : $l_2 = 2l_1$

Volume of material will be conserved. So, $A_1 l_1 = A_2 l_2$

$$\therefore \quad \frac{A_1}{A_2} = \frac{l_2}{l_1} = 2;$$

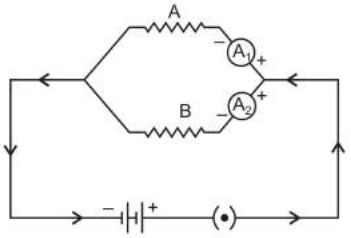
$$\frac{R_1}{R_2} = \frac{l_1}{l_2} \cdot \frac{l_1}{l_2} = \frac{l_1^2}{l_2^2} = \frac{1}{4}$$

$$\therefore \quad R_2 = 4R_1 = 80\ \Omega$$

19. **Two wires of equal lengths, one of copper and the other of manganin (an alloy) have the same thickness. Which one can be used for (*i*) electrical transmission lines, and (*ii*) electrical heating devices? Why?**

Ans. (*i*) Copper, as it has the lesser resistivity.
(*ii*) Manganin, as it has the comparatively higher resistivity, less oxidation even at high temperature.

20. **In the given circuit, resistors A and B are made up of same metal and are of the same length but, A is thicker than B.**



Which of the two ammeters will show a higher reading? Justify your answer.

Ans. Thicker wire has more cross-sectional area. So, it offers lesser resistance to the flow of current as $R \propto \frac{1}{A}$.
Hence, more current will flow through it.
In the given circuit, A is thicker than B.

So, $R_A < R_B$ (ρ is same)

$\Rightarrow$ $I_A > I_B$ (for same potential)

So, Ammeter A_1 will show higher reading.

21. The resistance of a metal wire of length 1 m is $10^4\ \Omega$ at 20 °C. If the diameter of the wire is 0.15 mm, find the resistivity of the metal at that temperature.

Ans. Radius of wire = 0.15/2 = 0.075 mm = 0.075×10^{-3} m

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

$= 3.14 \times (0.075 \times 10^{-3})^2$

$= 3.14 \times 0.005625 \times 10^{-6}\ m^2$

$= 0.0176 \times 10^{-6}\ m^2 = 1.76 \times 10^{-8}\ m^2$

Using, $\rho = R\frac{A}{l} = \frac{10^4 \times 1.76 \times 10^{-8}}{1}$

$= 1.76 \times 10^{-4}\ \Omega m$

22. (*a*) In a given ammeter, a student saw that needle indicates 12th division in ammeter while performing an experiment to verify Ohm's law. If ammeter has 10 divisions between 0 to 0.5 A, then what is the ammeter reading corresponding to 12th division?

(*b*) How do you connect an ammeter and a voltmeter in an electric circuit? [CBSE 2019]

Ans. (*a*) Least count of ammeter = $\frac{0.5}{10} = 0.05$ A

Thus, the value corresponding to 12 divisions = $0.05 \times 12 = 0.6$ A

(*b*) The ammeter is connected in series and a voltmeter is connected in parallel in an electric circuit.

Short Answer Type Questions 3 Marks

23. (*a*) Write the relationship between electrical resistance and electrical resistivity for a metallic conductor of cylindrical shape. Hence derive the SI unit of electrical resistivity.

(*b*) Find the resistivity of the material of a metallic conductor of length 2 m and area of cross-section $1.4 \times 10^{-6}\ m^2$. The resistance of the conductor is 0.04 ohm. [CBSE 2022]

Ans. (*a*) $\rho = R\frac{A}{l}$ **(½ Mark)**

SI unit of ρ = ohm $\times \frac{m^2}{m}$ **(½ Mark)**

= ohm × metre or Ωm **(½ Mark)**

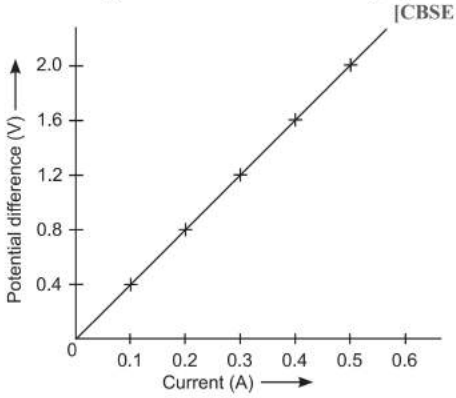
(*b*) $\rho = R\frac{A}{l}$ **(1 Mark)**

$= \frac{0.04\ \Omega \times 1.4 \times 10^{-6}\ m^2}{2\ m}$

$= 2.8 \times 10^{-8}\ \Omega m$ **(½ Mark)**

[CBSE Marking Scheme]

24. A V-I graph for a nichrome wire is given below. What do you infer from this graph? Draw a labelled circuit diagram to obtained such a graph. [CBSE 2020]



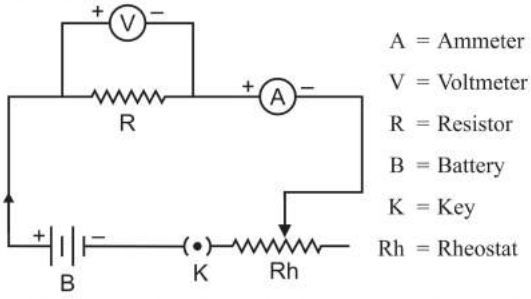
Ans. From the V–I graph for a nichrome wire, the straight line plot shows that as the current through a wire increases, the potential difference across the wire increases linearly – this is called Ohm's law.

i.e., $V \propto I$

or $\frac{V}{I} = \text{constant} = R$

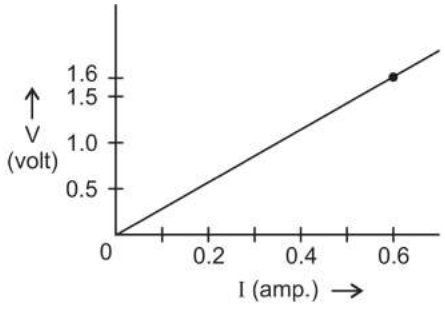
or $V = IR$

Circuit Diagram



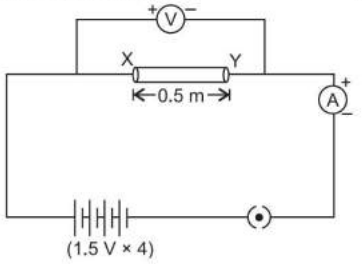
25. (*a*) Draw a closed circuit diagram consisting of a 0.5 m long nichrome wire XY, an ammeter, a voltmeter, four cells of 1.5 V each and a plug key.

(*b*) Following graph was plotted between V and I values :



What would be the values of V /I ratios when the potential difference is 0.8 V, 1.2 V and 1.6 V respectively? What conclusion do you draw from these values? [CBSE 2015]

Ans. (*a*)



(*b*) From the graph, when p.d is 1.6 volt and 0.6 A current the ratio of

$$\frac{V}{I} = \frac{1.6}{0.6} = 2.67\ \Omega.$$

Therefore, straight line nature of graph shows that the value of $\frac{V}{I}$ ratio for all potential difference of 0.8 V, 1.2 V and 1.6 volt will be same and is equal to 2.67 Ω.

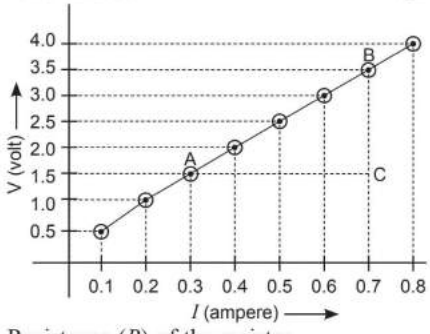
We conclude that at the given temperature, the resistance of wire is constant and is equal to 2.67 Ω.

26.

V (volts)	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0
I (amperes)	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8

Plot a graph between Current (*I*) and potential difference (*V*) and determine the resistance (*R*) of the resistor. [CBSE 2018]

Ans.



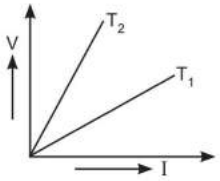
Resistance (*R*) of the resistor

= Slope of V – I line

$$= \frac{BC}{AC} = \frac{\Delta V}{\Delta I} = \frac{3.5 - 1.5}{0.7 - 0.3} = \frac{2.0}{0.4} = 5\ \Omega.$$

27. (*a*) Keeping the potential difference constant, the resistance of a circuit is doubled. By what factor does the current change in the circuit?

(*b*) The voltage – current (V – I) graph for a conductor at two different temperature T_1 and T_2 (V–I) is shown. At which of the two temperatures the resistance of the conductor is higher? Justify your answer. [HOTS]



Ans. (*a*) Using Ohm's law, $V = IR$

For constant potential difference

$$IR = \text{constant}$$

i.e., $I_1R_1 = I_2R_2$

$$\therefore \quad \frac{I_2}{I_1} = \frac{R_1}{R_2} = \frac{R}{2R} = \frac{1}{2} \Rightarrow I_2 = \frac{1}{2}I_1$$

So, current will reduce to half of its initial value.

(*b*) Slope of the V-I graph represents the resistance of the given conductor at given temperature. At the temperature T_2, the resistance of the conductor is higher as it has greater slope than that of at temperature T_1.

28. (*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. [CBSE 2018]

Ans. (*a*) The factors on which the resistance of a conductor in the shape of wire depends

(*i*) **Length of the conductor:** Resistance is directly proportional to length of the conductor.

(*ii*) **Area of cross section of the wire:** The resistance is inversely proportional to area of cross section of the wire.

(*iii*) The resistance of the conductor depends on the **nature of its material.**

(*iv*) **Temperature of the conductor:** Resistance is directly proportional to the temperature of the conductor.

(*b*) Metals are good conductor of electricity as they have free electrons to conduct whereas glass is a bad conductor of electricity as it does not allow electric current to pass through it due to non-availability of free electrons.

(*c*) The alloys are commonly used in electric heating device. This is because

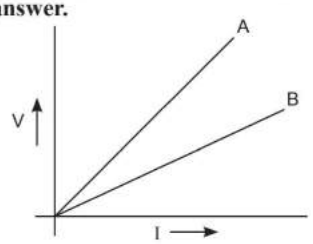
(*i*) Alloy are combination of two or more metals.

(*ii*) Its resistivity is higher than that of its constituent metals.

(*iii*) It neither gets oxidised nor burn easily at high temperature.

(*iv*) It shows less rapid variations of resistivity due to change in temperature.

29. V-I graph for two conducting wires A and B are shown. If both wires are of the same length and same thickness, which of the two is made of a material of high resistivity? Give justification for your answer. [CBSE 2023]



Ans. Greater is the slope of V-I graph, greater will be the resistance of given metallic wire. In the given graph, wire A has greater slope then B. Hence, wire A has greater resistance.

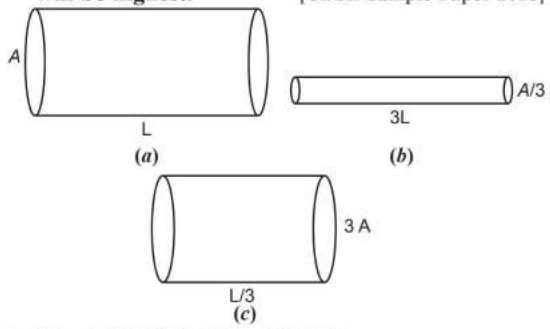
For the wires of same length and same thickness, resistance depends on the nature of material of the wire, i.e.

$$R_1 = \rho_1 \frac{l}{A} \quad \text{and} \quad R_2 = \rho_2 \frac{l}{A}$$

$$\Rightarrow \quad \frac{R_1}{R_2} = \frac{\rho_1}{\rho_2} \quad \text{or} \quad R \propto \rho$$

Hence, wire 'A' is made of a material of high resistivity.

30. The figure below shows three cylindrical copper conductors along with their face areas and lengths. Discuss in which geometrical shape the resistance will be highest. [CBSE Sample Paper 2018]



Ans. For geometrical shape shown in

Figure (*a*) $\quad R_a = \rho \frac{L}{A}$

Figure (*b*) $\quad R_b = \rho\left(\frac{3L}{A/3}\right) = \frac{9\rho L}{A} = 9R_a$

Figure (*c*) $\quad R_c = \rho\left(\frac{L/3}{3A}\right) = \frac{1}{9}.\frac{\rho L}{A} = \frac{1}{9}R_a$

Hence, $\quad R_b > R_a > R_c$

Since all the three conductors are of same material i.e. copper. Hence, they have the same resistivity.

i.e. $\quad \rho_a = \rho_b = \rho_c = \rho$

31. (*a*) List the factors on which the resistance of a uniform cylindrical conductor of a given material depends.

(*b*) The resistance of wire of 0.01 cm radius is 10 Ω. If the resistivity of the wire is 50×10^{-8} Ωm, find the length of this wire. [CBSE 2022]

Ans. (*a*) Resistance of a conductor depends upon

(*i*) length of the conductor (l) [$R \propto l$]

(*ii*) Area of cross-section of the conductor (A).

$\left[R \propto \frac{1}{A}\right]$

(*b*) Radius of wire, $r = 0.01$ cm

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

Resistance, $R = 10\ \Omega$

Resistivity, $\rho = 50 \times 10^{-8}\ \Omega$m

Using, $\quad R = \rho\frac{l}{A} = \rho\frac{l}{\pi r^2} \Rightarrow l = \frac{R\pi r^2}{\rho}$

$$\Rightarrow \quad l = \frac{10 \times 22 \times (10^{-4})^2}{7 \times 50 \times 10^{-8}} = \frac{22}{35} = 0.628 \text{ m}$$

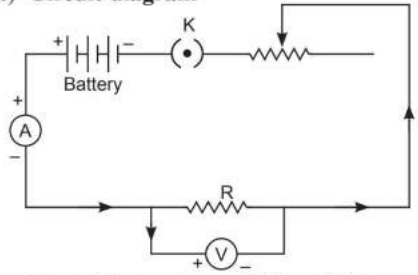
$$\Rightarrow \quad l = 0.62 \text{ m}$$

LA Long Answer Type Question 5 Marks

32. (*a*) Draw a labelled circuit diagram of the circuit used to show the variation of potential difference across the ends of a resistor with current flowing through it. If you use this circuit, what relation would you find between the voltmeter reading, V and the ammeter reading, I ?

(*b*) A wire of given material having length *l* and area of cross-section 'A' has a resistance of 4 Ω. Find the resistance of another wire of the same material having length *l*/2 and area of cross-section 2A. [CBSE 2021 (C)]

Ans. (*a*) **Circuit diagram**



The relation between 'V' and 'I' is

$$V \propto I \quad \text{or} \quad \frac{V}{I} = \text{constant}$$

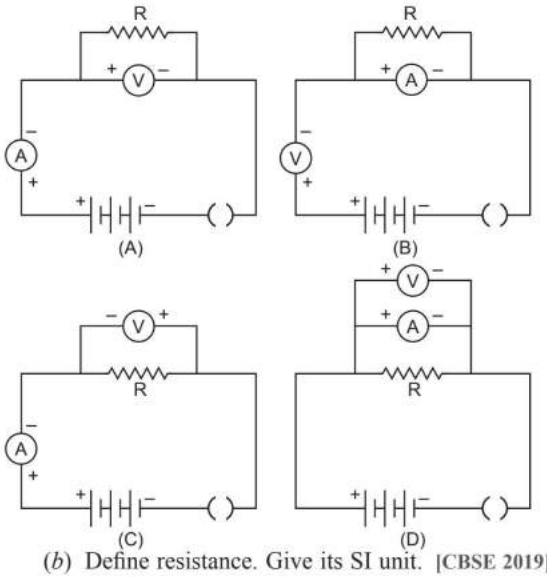
(*b*) For 1st wire, $\quad R_1 = \rho_1\frac{l}{A} = 4\ \Omega$

For 2nd wire,

$$R_2 = \rho\frac{l/2}{2A} = \frac{1}{4}R_1 \Rightarrow R_2 = \frac{1}{4} \times 4 = 1\ \Omega$$

PRACTICE QUESTIONS

1. A piece of wire of resistance R is drawn to double its length. The new resistance is
   (*a*) R (*b*) $2R$ (*c*) 4 (*d*) $\frac{R}{4}$
2. Two wires of equal length made of materials of resistivity ratio 1 : 2 and area of cross-section 3 : 2 have the potential drop across them in the ratio X : Y when connected in series. The ratio X : Y is
   (*a*) 3 : 1 (*b*) 2 : 5 (*c*) 5 : 2 (*d*) 1 : 3
3. A wire of length l, made of material resistivity ρ is cut into two equal parts. The resistivity of each parts is equal to
   (*a*) ρ (*b*) $\frac{\rho}{2}$ (*c*) 2ρ (*d*) 4ρ
4. Ohm's law fails
   (*a*) if temperature and pressure are not kept constant
   (*b*) to explain the behaviour of semiconductor
   (*c*) to explain the phenomenon of electric arc
   (*d*) all of above
5. The resistivity of copper is 1.7×10^{-8} Ωm. What length of copper wire of diameter 0.1 mm will have a resistance of 34 Ω?
6. (*a*) Which one the following is the correct set-up for studying the dependence of the current on the potential difference across a resistor and why?



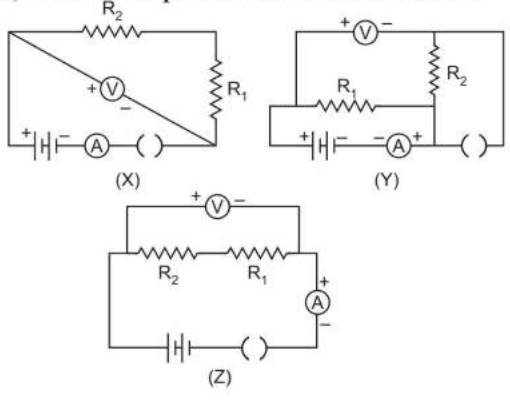
   (*b*) Define resistance. Give its SI unit. **[CBSE 2019]**
7. (*a*) Explain why a conductor offers resistance to the flow of current?
   (*b*) Differentiate between conductor, resistor and resistance.

TOPIC COVERED

Resistance of a System of Resistors

Multiple Choice Questions 1 Mark

1. **For determining the equivalent resistance of two resistors R_1 and R_2 connected in series, three students X, Y and Z set up their circuits as shown below:**



   The correct set up is that of
   (*a*) student X only
   (*b*) student Y only
   (*c*) student Z only
   (*d*) student X and Z
2. **If a person has five resistors each of value $\frac{1}{5}$ Ω, then the maximum resistance he can obtain by connecting them is**
   (*a*) 1 Ω (*b*) 5 Ω
   (*c*) 10 Ω (*d*) 25 Ω
3. **Two wires of same length and area made of two materials of resistivity ρ_1 and ρ_2 are connected in series to a source of potential V. The equivalent resistivity for the combination is**
   (*a*) $\rho_1 + \rho_2$ (*b*) $\frac{\rho_1\rho_2}{\rho_1+\rho_2}$
   (*c*) $\frac{(\rho_1+\rho_2)}{\rho_1\rho_2}$ (*d*) $\left(\frac{\rho_1+\rho_2}{2}\right)$

4. **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:** [CBSE 2020]
(*a*) 0.4 A (*b*) 0.6 A (*c*) 0.8 A (*d*) 1 A

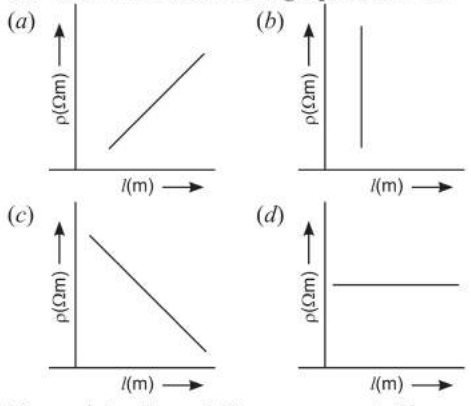
5. **In series combination of resistors, the flow of current across each resistor is**
(*a*) initially increases then decreases
(*b*) increases continuously
(*c*) decreases continuously
(*d*) remains the same

6. **In your daily life experience, which of the following is not used in series combination?**
(*a*) Decorative bulbs
(*b*) Fuses
(*c*) Domestic appliances
(*d*) All of them

7. **Pick out the incorrect statement from the following about series combination of resistors.**
(*a*) The current across each resistor is the same.
(*b*) The potential difference is same across each resistor
(*c*) Equivalent resistance is larger than the largest resistor
(*d*) It is used to decrease the current in the circuit.

8. **Three resistors of resistance 1 Ω, 2Ω and 3 Ω are connected in series combination and draw the current 0.5 A from the power source. The potential difference across the combination is**
(*a*) 3 V (*b*) 12 V (*c*) $\frac{1}{12}$ V (*d*) 6 V

9. **Raman wants to draw the graph to show how the resistivity (ρ) of a wire change with length (*l*) of the wire. What should his graph look like?**



10. **The resistor R_1 and R_2 are connected in parallel the equivalent resistance of the combination is**
(*a*) $R_1 + R_2$ (*b*) $R_1 - R_2$
(*c*) $\frac{R_1R_2}{R_1 + R_2}$ (*d*) $\frac{R_1 + R_2}{R_1R_2}$

11. **The equivalent resistance of the resistors connected in parallel is**
(*a*) greater than the greatest resistance
(*b*) smaller than the smallest resistance
(*c*) sum of all the resistance
(*d*) multiple of all the resistance

12. **Magnitude of current in different branches of the parallel combination is**
(*a*) same in each branch
(*b*) different in different branches
(*c*) divides as per number of branches
(*d*) none of the above

13. **The total current in parallel combination of three resistors is**
(*a*) $I = I_1 + I_2 + I_3$ (*b*) $I = \frac{I_1 + I_2}{I_3}$
(*c*) $I = (I_1 + I_2) \times I_3$ (*d*) $I = I_1 + I_2 - I_3$

14. **To get 2 Ω resistance, using only 6 Ω resistors, the number of them required is**
(*a*) 2 (*b*) 3 (*c*) 4 (*d*) 6

15. **Two devices are connected between two points say A and B in parallel. The physical quantity that will remain the same between the two points is**
(*a*) current (*b*) voltage
(*c*) resistance (*d*) none of these

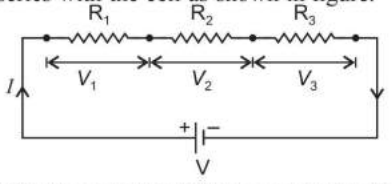
Answers

1. (*d*)
2. (*a*) For maximum resistance, all resistors should be connected in series.
$$\therefore \quad R_s = R_1 + R_2 + R_3 + R_4 + R_5$$
$$= \frac{1}{5} + \frac{1}{5} + \frac{1}{5} + \frac{1}{5} + \frac{1}{5}$$
$$= \frac{5}{5} = 1\ \Omega$$
3. (*d*) $$R = \rho \cdot \frac{2l}{A} = R_1 + R_2$$
$$\rho \cdot \frac{2l}{A} = \rho_1 \frac{l}{A} + \rho_2 \frac{l}{A} = (\rho_1 + \rho_2)\frac{l}{A}$$
$$\rho = \frac{\rho_1 + \rho_2}{2}$$
4. (*d*) 5. (*d*) 6. (*c*) 7. (*b*)
8. (*a*) 9. (*d*) 10. (*c*) 11. (*b*)
12. (*b*) 13. (*a*)
14. (*b*) Three resistors of 6 Ω is required to get 2 Ω because resultant is less than individual resistance when connected in parallel.
15. (*b*) In parallel combination voltage remains same across two points.

VSA Very Short Answer Type Questions 2 Marks

16. Apply Ohm's law to obtain the relation for combined resistance when three resistors R_1, R_2 and R_3 are connected in series.

Ans. Series combination: Consider a system in which three resistances, R_1, R_2 and R_3 respectively are connected in series with the cell as shown in figure.



Let V be the potential difference maintained by the cell across the combination and I be the current flowing through each resistor.

Using Ohm's law, potential difference across each resistor is

$$V_1 = IR_1,\ V_2 = IR_2,\ V_3 = IR_3$$

but $$V = V_1 + V_2 + V_3$$

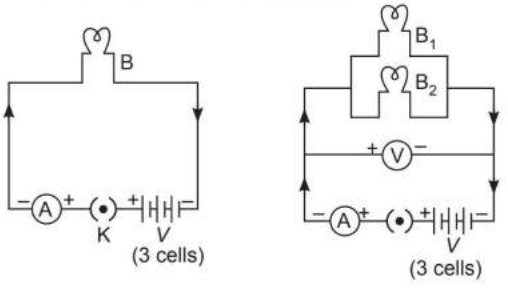
$$IR_S = IR_1 + IR_2 + IR_3 = I(R_1 + R_2 + R_3)$$

$$\Rightarrow \quad R_S = R_1 + R_2 + R_3$$

where R_S is the equivalent resistance of the series combination.

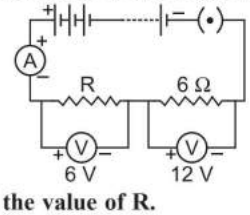
17. Draw a schematic diagrams of an electric circuit comprising of 3 cells and an electric bulb, ammeter, plug-key in the ON mode and another with same components but with two bulbs in parallel and a voltmeter across the combination.

Ans.



SA Short Answer Type Questions 3 Marks

18. A circuit is shown in the diagram given below.



(a) Find the value of R.

(b) Find the reading of the ammeter.

(c) Find the potential difference across the terminals of the battery.

Ans. (*a*) P.d across 6 Ω = 12 V

$\therefore$ Current through 6 Ω,

$$I = \frac{V}{R} = \frac{12}{6} = 2 \text{ A}$$

As R and 6 Ω are connected in series. So, the current through R is 2 A.

Using Ohm's law, $R = \frac{V}{I} = \frac{6}{2} = 3\ \Omega$

(*b*) Reading of ammeter = 2 A

(*c*) P.d across the terminals of the battery

$$V = V_1 + V_2$$
$$= 6 + 12 = 18 \text{ V}$$

19. Two resistors 3 Ω and unknown resistor are connected in a series across a 12 V battery. If the voltage drop across the unknown resistor is 6 V, find

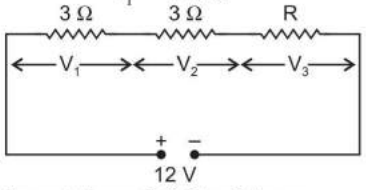
(a) potential across 3 Ω resistance

(b) the current through unknown resistor 'R'

(c) equivalent resistance of the circuit.

Ans. (*a*) Same current will flow through each resistor of series combination, the potential drop across both 3 Ω resistor will be same ($V_1 = V_2$). In series, applied potential,

$$V = V_1 + V_2 + V_3$$
$$\Rightarrow \quad 12 = V_1 + V_1 + 6$$
$$2V_1 = 12 - 6$$
$$V_1 = 3 \text{ volt}$$



(*b*) Current through 3 Ω resistance

$$I = \frac{V}{R} = \frac{3}{3} = 1 \text{ A}$$

So, current through unknown resistance R is 1 A.

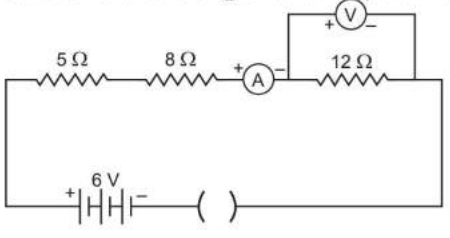
(*c*) Unknown resistance

$$R = \frac{V}{I} = \frac{6}{1} = 6\ \Omega$$

$\therefore$ Equivalent resistance,

$$R_s = R_1 + R_2 + R_3$$
$$= 3 + 3 + 6 = 12\ \Omega.$$

20. Consider the following circuit: [CBSE 2018(C)]



What would be the readings of the ammeter and the voltmeter when key is closed? Give reason to justify your answer.

Ans. All the resistor are connected in series

$\therefore\ R = R_1 + R_2 + R_3 = 5 + 8 + 12 = 25\ \Omega$

Current, $I = \dfrac{V}{R} = \dfrac{6}{25} = 0.24\ \text{A}$

Hence current through 12 Ω resistor

$= \dfrac{6}{25} = 0.24\ \text{A}$

Hence, reading of voltmeter

$V = IR = \dfrac{6}{25} \times 12 = \dfrac{72}{25}$

or $V = 2.88\ \text{V}$

21. Series arrangements are not used for domestic circuits. List any three reasons.

Ans. Series arrangements are not used for domestic circuit because

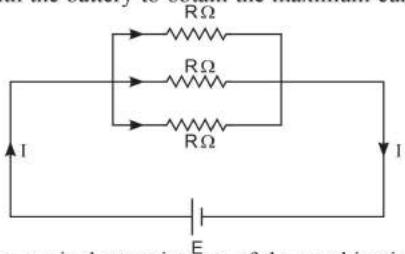
(*i*) The electrical appliances need current of widely different values to operate properly.

(*ii*) In series arrangement, when one component fails, the circuit is broken and none of the components works.

(*iii*) All electrical appliances work at a constant voltage. But in series circuit, the current is constant throughout the electric circuit and potential is different across the different components. So, series arrangement is not suitable for domestic circuits.

22. You have three resistors of resistance *R* Ω each and a battery of '*E*' volts. How would you connect these resistors with a battery to obtain maximum current? Draw circuit diagram to illustrate your answer and also calculate the current drawn from the battery. **[CBSE 2016]**

Ans. All three resistors should be connected in parallel with the battery to obtain the maximum current.



The equivalent resistance of the combination

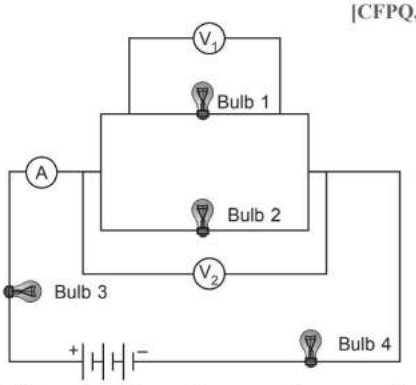
$$\frac{1}{R_p} = \frac{1}{R} + \frac{1}{R} + \frac{1}{R} = \frac{3}{R}$$

$$\Rightarrow \quad R_p = \frac{R}{3}$$

By Ohm's law

$$I = \frac{V}{R} = \frac{E}{R/3} = \frac{3E}{R}$$

23. Answer the questions based on the electric circuit shown below. All the four bulbs are identical. **[CFPQ, CBSE]**



(*a*) How does the voltage reading on voltmeter 1 compare with the voltage reading on voltmeter 2?

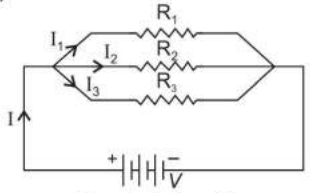
(*b*) Identify the bulb(s) through which a current equal to the reading on the ammeter flows.

Ans. (*a*) The voltage reading on voltmeter 1 will be the same as the reading on voltmeter 2.

(*b*) • Bulb 3, and • Bulb 4

24. Deduce the expression for the equivalent resistance of the parallel combination of three resistors R_1, R_2 and R_3.

Ans. Consider the following parallel circuit shown below :



[Parallel circuit]

Let I_1, I_2 and I_3 be the current flow through the resistor R_1, R_2 and R_3 connected in parallel.

Using Ohm's law, current through each resistor is

$$I_1 = \frac{V}{R_1},\ I_2 = \frac{V}{R_2} \text{ and } I_3 = \frac{V}{R_3}$$

Let their equivalent resistance be R_P then

$$V = IR_P \ \Rightarrow \ I = \frac{V}{R_P}$$

Total current through the circuit is

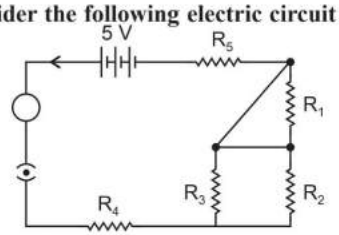
$$I = I_1 + I_2 + I_3$$

or $$\frac{V}{R_P} = \frac{V}{R_1} + \frac{V}{R_2} + \frac{V}{R_3}$$

or $$\frac{V}{R_P} = V\left(\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}\right)$$

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

25. Consider the following electric circuit :



(*a*) Which two resistors are connected in series?
(*b*) Which two resistors are connected in parallel?
(*c*) If every resistor of the circuit is of 2 Ω, what current will flow in the circuit? [HOTS]

Ans. For the given circuit

(*a*) R_5 and R_4 with Parallel combination of R_2 and R_3 are in series

(*b*) R_2 and R_3 are in parallel.

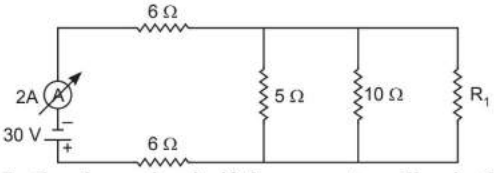
(*c*) R_2 and R_3 in parallel gives $R_p = 1\ \Omega$

R_p, R_5 and R_4 are in series. So, $R_{eq} = 5\ \Omega$

R_1 is not to be taken as it is shorted.

Current flowing $= I = \dfrac{V}{R_{eq}} = \dfrac{5}{5} = 1$ A

26.



In the above circuit, if the current reading in the ammeter A is 2A, what would be the value of R_1? [CBSE Sample Paper 2022]

Ans. 5 ohm, 10 ohm and R_1 are in parallel

$$\frac{1}{R_p} = \frac{1}{5} + \frac{1}{10} + \frac{1}{R_1}$$

$$\frac{1}{R_p} = \frac{(2+1)}{10} + \frac{1}{R_1} = \frac{3}{10} + \frac{1}{R_1}$$

$$\frac{1}{R_p} = \frac{(3R_1+10)}{10R_1}$$

$$R_p = \frac{10R_1}{(3R_1+10)}$$

Now, 6 ohm, 6 ohm and R_p are in series

Thus, $$R_{eq} = 12 + \frac{10R_1}{(3R_1+10)} \quad ...(1)$$

$$V = IR_{eq}$$

From the circuit

$$R_{eq} = \frac{30}{2} = 15\ \Omega \quad ...(2)$$

Equating (1) and (2)

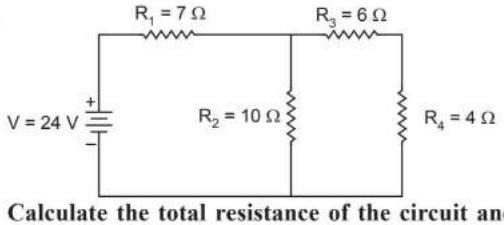
$$12 + \frac{10R_1}{(3R_1+10)} = 15$$

$$\frac{10R_1}{(3R_1+10)} = 3$$

$$10R_1 = (9R_1 + 30)$$

Thus, $R_1 = 30$ ohm.

27.



Calculate the total resistance of the circuit and find the total current in the circuit. [CBSE Sample Paper 2022]

Ans. R_3 and R_4 are in series. Hence their equivalent resistance

$$R_{S_1} = R_3 + R_4$$
$$= 6 + 4 = 10\ \Omega$$

Now R_2 and R_{S_1} are in parallel

$$\therefore \quad R_p = \frac{R_2 \,.\, R_{S_1}}{R_2 + R_{S_1}}$$

$$= \frac{10 \times 10}{10+10} = \frac{100}{20} = 5\ \Omega$$

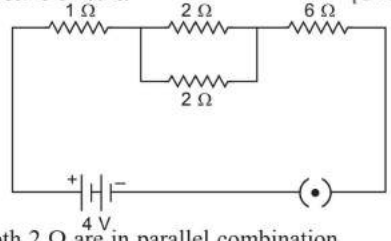
Now R_1 and R_p are in series

$$\therefore \quad R_s = R_1 + R_p = 7 + 5 = 12\ \Omega$$

By Ohm's law, $I = \dfrac{V}{R_s}$

$$= \frac{24}{12} = 2 \text{ A}$$

28. Find the current following through the following electric circuit. [CBSE 2022C]



Ans. Both 2 Ω are in parallel combination

$$\therefore \quad \frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R}$$

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

$$R_p = 1\ \Omega$$

Now, 1 Ω, R_p and 6 Ω are in series

$$\therefore \quad R_s = 1 + R_p + 6 = 1 + 1 + 6 = 8\ \Omega$$

So, current in the circuit, from Ohm's law

$$I = \frac{V}{R_s} = \frac{4\text{ V}}{8\ \Omega} = 0.5 \text{ A}$$

29. List three advantage of connecting electrical appliances in parallel with the mains instead of connecting them in series. [CBSE 2022(C)]

Ans. Three advantages are

(*i*) Proper voltage to every appliances.

(*ii*) Separate switches for each appliances.

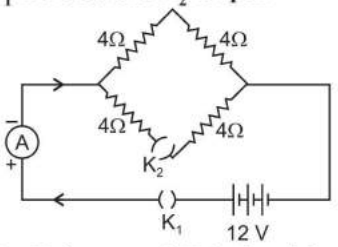
(*iii*) If one appliances fail other remains functional.

30. Calculate the electric current in the given circuit when

(*a*) key K_1 is open and K_2 is closed

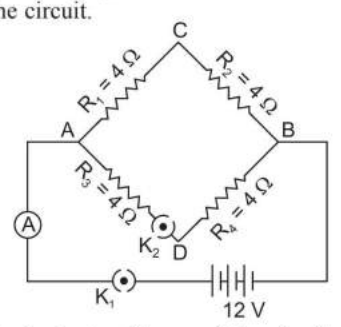
(*b*) both the keys are closed

(*c*) K_1 is closed and K_2 is open [HOTS]



Ans. (*a*) Key K_1 is open and K_2 is closed, then no current flows in the circuit as circuit is an open circuit.

(*b*) **Both the keys are closed :** Current flows through the circuit.



Equivalent resistance of the circuit,

$$\frac{1}{R} = \frac{1}{R_1 + R_2} + \frac{1}{R_3 + R_4}$$

$$= \frac{1}{4+4} + \frac{1}{4+4}$$

$$= \frac{1}{8} + \frac{1}{8} = \frac{2}{8} = \frac{1}{4}$$

So, $R = 4\ \Omega$

Electric current,

$$I = \frac{V}{R} = \frac{12}{4} = 3\ \text{A}$$

(*c*) ***K_1* is closed and *K_2* is open**

When K_2 is open, the part ADB will become an open circuit, So no current will flow in the ADB part.

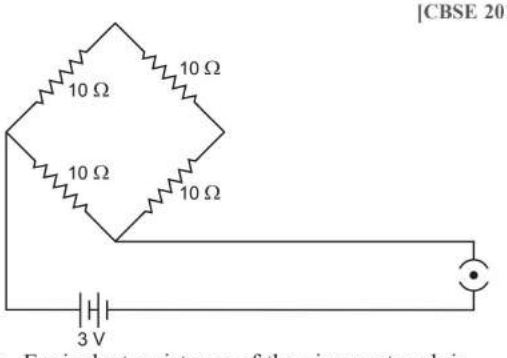
$\therefore$ Net resistance of circuit,

$$R = R_1 + R_2 = 4 + 4 = 8\ \Omega$$

$\therefore$ Electric current,

$$I = \frac{V}{R} = \frac{12}{8} = \frac{3}{2} = 1.5\ \text{A}$$

31. Find the current drawn from the battery by the network of four resistors shown in the figure. [CBSE 2015]



Ans. Equivalent resistance of the given network is

$$\frac{1}{R} = \frac{1}{R_4} + \frac{1}{R_1 + R_2 + R_3}$$

$$= \frac{1}{10} + \frac{1}{10+10+10}$$

$$= \frac{1}{10} + \frac{1}{30} = \frac{3+1}{30} = \frac{4}{30}$$

$\therefore$ $$R = \frac{30}{4} = 7.5\ \Omega$$

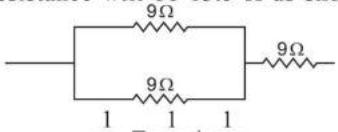
Current drawn from the battery

$$I = \frac{V}{R} = \frac{3}{7.5} = \frac{30}{75} = \frac{2}{5}$$

$\Rightarrow$ $$I = 0.4\ \text{A}$$

32. Show how would you join three resistors, each of resistance 9 Ω so that the equivalent resistance of the combination is (*a*) 13.5 Ω, (*b*) 6 Ω? [CBSE 2018]

Ans. (*a*) When two 9 Ω resistances are in parallel and the third is in series combination to this, the equivalent resistance will be 13.5 Ω as shown below:



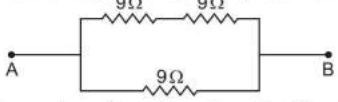
$$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2}$$

$$\frac{1}{R_p} = \frac{1}{9} + \frac{1}{9} = \frac{2}{9}$$

$$R_p = \frac{9}{2}\Omega = 4.5\ \Omega$$

$$R_s = R_p + R_3 = 4.5 + 9 = 13.5\ \Omega$$

(*b*) When two 9 Ω resistances are in series and the third is in parallel to them, then it will be 6 Ω.



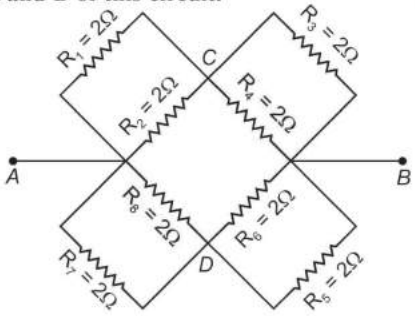
For series, $R_s = R_1 + R_2 = 9 + 9 = 18\ \Omega$

For parallel,

$$\frac{1}{R_p} = \frac{1}{R_s} + \frac{1}{R_3} = \frac{1}{18} + \frac{1}{9} = \frac{3}{18} = \frac{1}{6}$$

Therefore, $R_p = 6\ \Omega$

33. Find the equivalent resistance across the two ends A and B of this circuit. [HOTS]



Ans. The equivalent resistance of the resistors R_1 and R_2 in parallel between A and C is

$$\frac{1}{R_{AC}} = \frac{1}{R_1} + \frac{1}{R_2} = \frac{1}{2} + \frac{1}{2} = \frac{2}{2} = 1$$

$\therefore \quad R_{AC} = 1\ \Omega$

Similarly, between B and C,

$$\frac{1}{R_{BC}} = \frac{1}{R_3} + \frac{1}{R_4} = \frac{1}{2} + \frac{1}{2} = 1$$

$\therefore \quad R_{BC} = 1\ \Omega$

Now, R_{AC} and R_{BC} are joined in series

$\therefore \quad R' = R_{AC} + R_{BC} = 1 + 1 = 2\ \Omega$

Parallel combination of R_8 and R_7 between A and D gives

$$R_{AD} = 1\ \Omega$$

and parallel combination of R_5 and R_6 between D and B gives

$$R_{DB} = 1\ \Omega$$

The equivalent resistance of series combination of R_{AD} and R_{DB} is

$$R'' = R_{AD} + R_{DB} = 1 + 1 = 2\ \Omega$$

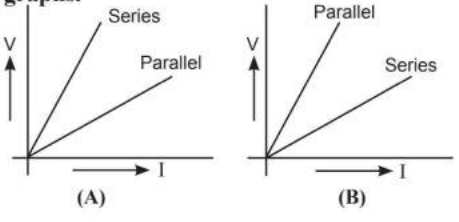
R' and R'' are connected in parallel.

The equivalent resistance is

$$\frac{1}{R_{eq}} = \frac{1}{R'} + \frac{1}{R''} = \frac{1}{2} + \frac{1}{2} = 1$$

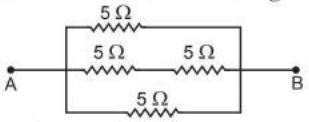
$\therefore \quad R_{eq} = 1\ \Omega$

34. (*a*) Two students perform the experiments on series and parallel combinations of two given resistors R_1 and R_2 and plot the following V-I graphs.



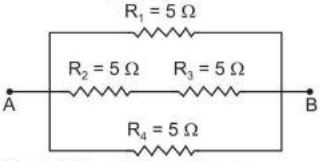
Which of the two diagrams correctly represents the labels 'series and parallel' on the plotted curves? Justify your answer. [HOTS]

(*b*) Find the equivalent resistance across the two ends A and B of the following circuit.



Ans. (*a*) In series, the resistances are added so, the equivalent resistance will be more than the case when they are connected in parallel. Also the slope (V/I) of given $V - I$ graph gives the resistance. Slope (V/I) is more for series and less for parallel in 'A'. So graph 'A' is correct.

(*b*)



R_2 and R_3 are in series, so

$$R_s = R_2 + R_3 = 5 + 5 = 10\ \Omega$$

R_1, R_s and R_4 are in parallel. So

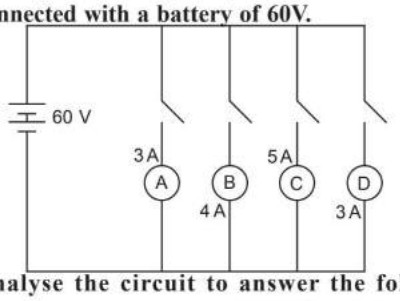
$$\frac{1}{R_P} = \frac{1}{R_1} + \frac{1}{R_s} + \frac{1}{R_4} = \frac{1}{5} + \frac{1}{10} + \frac{1}{5}$$

$$\frac{1}{R_P} = \frac{5}{10}$$

or $\quad R_P = 2\ \Omega$

LA Long Answer Type Questions 5 Marks

35. In the given circuit, A, B, C and D are four lamps connected with a battery of 60V.



Analyse the circuit to answer the following questions. [CBSE Sample Paper 2021]

(*i*) What kind of combination are the lamps arranged in (series or parallel)?

(*ii*) Explain with reference to your above answer, what are the advantages (any two) of this combination of lamps?

(*iii*) Explain with proper calculations which lamp glows the brightest?

(*iv*) Find out the total resistance of the circuit.

Ans. (*i*) The lamps are in parallel. **(1 Mark)**

(*ii*) **Advantages:**
If one lamp is faulty, it will not affect the working of the other lamps. They will also be using the full potential of the battery as they are connected in parallel. **(1 Mark)**

(*iii*) The lamp with the highest power will glow the brightest. **(1 Mark)**

$P = VI$

In this case, all the bulbs have the same voltage. But lamp C has the highest current.

Hence, for Lamp C,

$P = 5 \times 60$ Watt **(1 Mark)**

$= 300$ W. (the maximum).

(*iv*) The total current in the circuit $= 3 + 4 + 5 + 3$ A
$= 15$A **(1 Mark)**

The Voltage = 60 V

$V = IR$ and hence $R = \dfrac{V}{I} = \dfrac{60\,V}{15\,\text{A}} = 4\ \Omega$

[CBSE Marking Scheme]

36. (*a*) When two resistors of resistance R_1 and R_2 are connected in parallel, the net resistance is 3 Ω. When connected in series its value is 16 Ω. Calculate the value of R_1 and R_2.

(*b*) Calculate the ratio of current drawn in both the cases from the power supply of 24 V.

Ans. (*a*) R_1 and R_2 are in parallel

$$\therefore \quad \frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R_2}$$

$$\Rightarrow \quad R_p = \frac{R_1 R_2}{R_1 + R_2} = 3 \qquad \ldots(i)$$

When R_1 and R_2 are in series combination,

$$R_s = R_1 + R_2 = 16\ \Omega \qquad \ldots(ii)$$

From equation (*i*) and (*ii*), we get

$$R_1 R_2 = 3(R_1 + R_2)$$
$$= 3 \times 16 = 48\ \Omega \qquad \ldots(iii)$$

Using,

$$(R_1 - R_2)^2 = (R_1 + R_2)^2 - 4R_1 R_2$$
$$= (16)^2 - 4 \times 48 = 64$$

$$\Rightarrow \quad R_1 - R_2 = 8 \qquad \ldots(iv)$$

On solving equation (*ii*) and (*iv*), we get

$R_1 = 12\ \Omega$ and $R_2 = 4\ \Omega$

(*b*) When R_1 and R_2 are in parallel, $R_p = 3\ \Omega$

From Ohm's law,

$$\therefore \quad I_p = \frac{V}{R_p} = \frac{24}{3} = 8\ \text{A}$$

When R_1 and R_2 are in series, $R_s = 16\ \Omega$

$$\therefore \quad I_s = \frac{V}{R_s} = \frac{24}{16} = \frac{3}{2} = 1.5\ \text{A}$$

$$\therefore \quad I_p : I_s = 8 : \frac{3}{2} = 16 : 3$$

PRACTICE QUESTIONS

1. A wire of resistance 20 Ω is bent in the form of a circle. The effective resistance between two points at the ends of any diameter of the circle is

(*a*) 10 Ω (*b*) 40 Ω
(*c*) 5 Ω (*d*) 20 Ω

2. The two identical resistors are connected first in series and then in parallel respectively. The ratio of their equivalent resistance would be

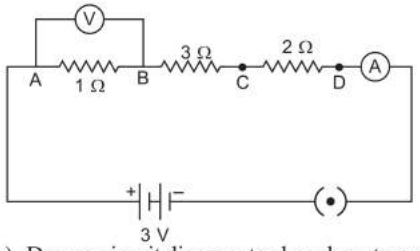
(*a*) 4 : 1 (*b*) 1 : 4
(*c*) 2 : 3 (*d*) 3 : 2

3. If four identical resistors, of resistance 8 ohm, are first connected in series so as to give an effective resistance R_s and then connected in parallel so as to give an effective resistance R_p, then the ratio of $\dfrac{R_s}{R_p}$ is **[CBSE 2023]**

(*a*) 32 (*b*) 12
(*c*) 0.5 (*d*) 16

4. A 9 Ω resistance is cut into three equal parts and connected in parallel. Find the equivalent resistance of the combination.

5. How would the reading of voltmeter (V) change if it is connected between 'B' and 'C'? Justify your answer.



6. (*a*) Draw a circuit diagram to show how two resistors are connected in parallel?

(*b*) In the above circuit, if the two resistors are 5 Ω and 10 Ω respectively, how does the potential difference across each resistor compare?

7. Two students perform experiments on two given resistors R_1 and R_2 and plot the V–I graph shown by diagram 1 and 2. If $R_1 > R_2$, which of two diagrams correctly represent the situation on the plotted curves? Justify your answer.

Diagram - 1

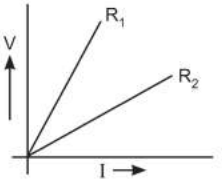
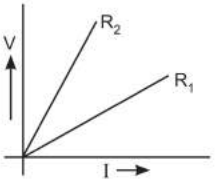
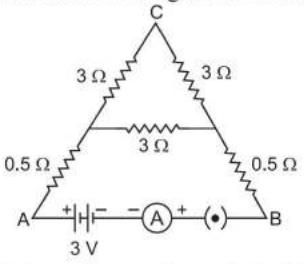


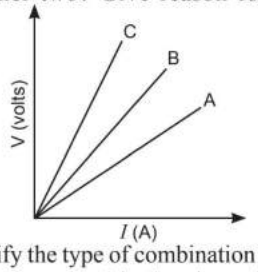
Diagram - 2



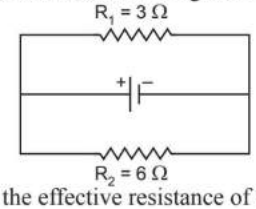
8. Five resistors are connected in a circuit as shown. Find the ammeter reading when circuit is closed.



9. Three V–I graphs are drawn individually for two resistors and their series combination. Out of A, B, C which one represents the graph for series combination of the other two? Give reason for your answer.

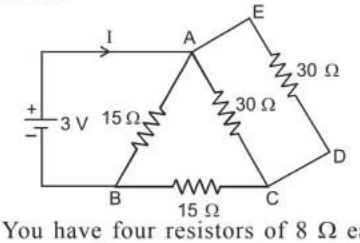


10. (*a*) Identify the type of combination in which R_1 and R_2 are connected in the given circuit diagram.



(*b*) Find the effective resistance of the combination.

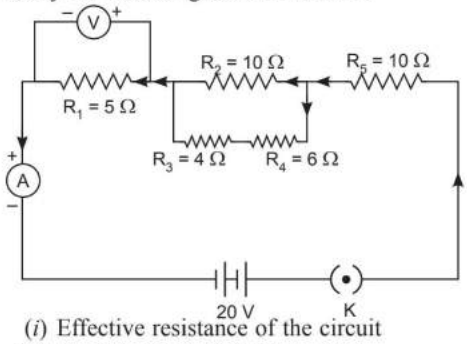
11. (*a*) Find the value of current *I* in the circuit given below:



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

12. (*a*) Find the minimum resistance that can be made using four resistors, each of 20 Ω.

(*b*) Study the following circuit and find :



(*i*) Effective resistance of the circuit

(*ii*) Current drawn from the battery

(*iii*) Potential difference across the 5 Ω resistor

[CBSE 2022]

TOPIC COVERED

Heating Effect of Electric Current

Multiple Choice Questions — 1 Mark

1. **The resistance of resistor is reduced to half of its initial value. If other parameters of the circuit remain unchanged, the amount of heat produced in the resistor will become** **[CBSE 2023, 20]**
   (*a*) four times (*b*) two times
   (*c*) half (*d*) one fourth

2. **In a resistive circuit if the current is increased to two times, the percentage change in the amount of heat dissipated in the circuit would be:**
   (*a*) 400% (*b*) 300%
   (*c*) 200% (*d*) 100%

3. **Elements of electric heating devices, such as bread toasters and electric iron are generally made up of**
   (*a*) metal (*b*) non-metal
   (*c*) alloy (*d*) tin

4. **According to Joule's law of heating, the heat produced in a resistor in time *t* is**
   (*a*) $H = I^2Rt$ (*b*) $H = IR^2t$
   (*c*) $H = V^2It$ (*d*) All of these

5. **Which of the following is used almost exclusively for filaments of electric lamp?**
   (*a*) Copper
   (*b*) Silver
   (*c*) Tungsten
   (*d*) Titanium

6. Water boils in an electric kettle in 18 minutes after switching on. If the length of heating wire is decreased to 1/3rd of its initial value, then the same amount of water will boil with the same supply of voltage in

(*a*) 6 minutes (*b*) 12 minutes
(*c*) 54 minutes (*d*) 18 minutes

7. 50 J heat is produced each second in a 2 Ω resistor. The potential difference across the resistor is

(*a*) 10 V (*b*) 25 V
(*c*) 50 V (*d*) 100 V

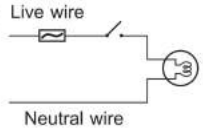
8. An electric fuse is based on

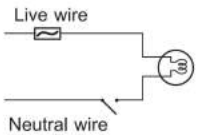
(*a*) the chemical effect of current
(*b*) the magnetic effect of current
(*c*) the heating effect of current
(*d*) none of these

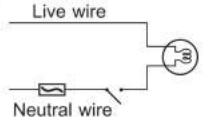
9. The fuse wire should have a

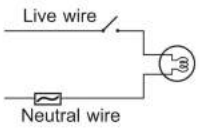
(*a*) low melting point (*b*) high resistance
(*c*) high melting point (*d*) both (*a*) and (*b*)

10. Which circuit shows the correct and safe position for the fuse and switch?

(*a*)


(*b*)


(*c*)


(*d*)


Answers

1. (*b*) Heat produced,

$$H \propto \frac{1}{R} \qquad (\because V = \text{Constant})$$

$$\therefore \quad \frac{H_1}{H_2} = \frac{R_2}{R_1}$$

$$= \frac{R/2}{R} = \frac{1}{2}$$

$$\therefore \quad H_2 = 2H_1$$

2. (*b*) The percentage change in heat dissipation

$$= \left(\frac{H' - H}{H}\right) \times 100 = \left(\frac{I'^2 - I^2}{I^2}\right) \times 100$$

$$= 3 \times 100 = 300\%$$

3. (*c*) **4.** (*a*) **5.** (*c*) **6.** (*a*)

7. (*a*) From Joule's law of heating,

$$H = I^2Rt = \frac{V^2t}{R} \Rightarrow V^2 = \frac{HR}{t} = \frac{50 \times 2}{1}$$

$$V^2 = 100 \Rightarrow V = 10 \text{ V}$$

8. (*c*) **9.** (*d*) **10.** (*a*)

VSA Very Short Answer Type Questions 2 Marks

11. Explain the role of fuse in series with any electrical appliance in an electric circuit. Why should a fuse with defined rating for an electric circuit not be replaced by one with a larger rating?

Ans. Fuse wire is a safety device connected in series with the live wire of circuit. It has high resistivity and low melting point. It melts when a sudden urge of large current passes through it and disconnects the entire circuit from the electrical supply. But, in case if we use a larger rating instead of a defined rating, then it will not protect the circuit as high current will easily pass through it and it will not melt.

12. In what time is 400 joules of heat produced across a 16 Ω resistor at 80 V potential difference?

Ans. Given: $H = 400$ J, $t = ?$, $R = 16\ \Omega$, $V = 80$ V

Using, $$H = \frac{V^2t}{R} \Rightarrow 400 = \frac{80^2 \times t}{16}$$

$$\Rightarrow \quad t = \frac{400 \times 16}{80^2} \text{ or } t = 1 \text{ s}$$

SA Short Answer Type Questions 3 Marks

13. State the factors on which the heat produced in a current carrying conductor depends. Give one practical application of this effect.

Ans.
- According to Joule's law of heating effect, the heat (H) produced in a current carrying conductor depends upon
  - (*i*) square of current pass through it ($H \propto I^2$).
  - (*ii*) resistance of the conductor ($H \propto R$).
  - (*iii*) time for which current is passed in conductor ($H \propto t$).
- Practical application of heating effect
  (*i*) Electric heater (*ii*) Fuse (*Any one*)

14. A fuse wire melts at 5 A. If it is desired that the fuse wire of the same material melt at 10 A, then should the new fuse wire be of smaller or larger radius than the earlier one? Give reason for your answer.

Ans. Let the resistance of fuse wire that melts at 5 A be R_1. Then heat produced every seocnd is,

$$H = I_1^2R_1 = 5^2R_1 = 25R_1 \qquad \ldots(i)$$

Let the resistance of new fuse wire for current I_2 be R_2. For the same heat,

$$H = I_2^2R_2 = 10^2R_2 = 100R_2 \quad \ldots(ii)$$

From equation (*i*) and (*ii*), we have

$$100R_2 = 25R_1$$

$$\Rightarrow \quad \frac{R_2}{R_1} = \frac{1}{4}$$

But $R \propto \frac{1}{A}$ (A = Area of cross-section of wire)

$\therefore \quad \frac{R_2}{R_1} = \frac{A_1}{A_2} = \frac{1}{4} \Rightarrow A_2 = 4A_1$

$\Rightarrow \quad \pi r_2^2 = 4\pi r_1^2 \Rightarrow r_2 = 2r_1$

Therefore, the radius of new fuse wire would be larger and twice that of earlier one.

15. (*a*) Why does the fuse wire not break when the allowed magnitude of current flows in the circuit?

(*b*) An electric heater of resistance 15 Ω draws 5 A current from the service mains in 1.5 hours. Calculate the rate at which heat is developed in the heater.

Ans. (*a*) When small magnitude of current flows through the fuse wire, small amount of heat is produced. This amount of heat is not enough to melt the fuse wire and transmitted to the surroundings.

(*b*) The rate at which heat is developed

$$\frac{H}{t} = \frac{I^2Rt}{t} = I^2R = (5)^2 \times 15$$
$$= 25 \times 15 = 375 \text{ Js}^{-1}$$

PRACTICE QUESTIONS

1. Heat produced in a wire of resistance R due to current flowing at constant potential difference for a given time is proportional to
   (*a*) R^2 (*b*) R
   (*c*) $\frac{1}{R}$ (*d*) $\sqrt{R}$
2. A coil develops heat at the rate of 800 Js^{-1} when 20 volt is applied across its end. The resistance of the coil is
   (*a*) 40 Ω (*b*) 20 Ω
   (*c*) 2 Ω (*d*) 0.2 Ω
3. Mention two practical disadvantages of heating effect of electric current.
4. An electric heater of resistance 6 Ω is operated for 10 minutes on a 220 V supply line. Calculate the amount of heat energy liberated in that time.
5. A current of 3 A passing through a conductor produce 90 J of heat in 10 seconds. What is the resistance of that conductor?
6. (*a*) State the working principle of an electric fuse.
   (*b*) Out of 5 A fuse and 15 A fuse which will you prefer to use for the lighting circuit?
   (*c*) Given reason:
   (*i*) Electric bulbs are usually filled with chemically inactive gases.
   (*ii*) Fuse wire is placed in series with the device.

TOPICS COVERED

Electric Power and Energy

Multiple Choice Questions 1 Mark

1. If R_1 and R_2 be the resistance of the filament of 40 W and 60 W respectively operating 220 V, then
   (*a*) $R_1 < R_2$ (*b*) $R_2 < R_1$
   (*c*) $R_1 = R_2$ (*d*) $R_1 \geq R_2$

2. The resistance of hot filament of the bulb is about 10 times the cold resistance. What will be the resistance of 100 W-220 V lamp, when not in use?
   (*a*) 48 Ω (*b*) 400 Ω
   (*c*) 484 Ω (*d*) 48.4 Ω

3. If P and V are the power and potential of device, the power consumed with a supply potential V_1 is
   (*a*) $\frac{V_1^2}{V^2} P$ (*b*) $\frac{V^2}{V_1^2} P$
   (*c*) $\frac{V}{V_1} P$ (*d*) $\frac{V_1}{V} P$

4. For maximum power consumption, all given resistors should be connected in
   (*a*) parallel
   (*b*) series
   (*c*) some in parallel and some in series
   (*d*) none of these

5. Which of the following does not represent electric power? [CBSE 2020]
   (*a*) I^2R (*b*) IR^2
   (*c*) VI (*d*) V^2/R

6. One kilowatt hour is equal to
   (*a*) 36×10^6 J (*b*) 3.6×10^6 J
   (*c*) 0.36×10^6 J (*d*) all of these

7. If R_1 and R_2 are respectively the filament resistances of a 200 W bulb and 100 W bulb design to operate on the same voltage, then
   (*a*) $R_1 = 4R_2$ (*b*) $R_2 = 4R_1$
   (*c*) $R_2 = 2R_1$ (*d*) $R_1 = 2R_2$

8. **Two heater wires of same length and same material but of different thickness are connected in series across a power supply. The power dissipated will be**
   (*a*) more in thicker wire
   (*b*) more in thinner wire
   (*c*) same in both
   (*d*) cannot say

Answers

1. (*b*) Using power, $P = \frac{V^2}{R}$ or $R = \frac{V^2}{P}$

   For the same voltage, $R \propto \frac{1}{P}$

   More the power, lesser the resistance.
   Accordingly, $R_2 < R_1$

2. (*c*) $R = \frac{V^2}{P} = \frac{220 \times 220}{100} = 484\ \Omega$

3. (*a*) $R = \frac{V^2}{P}$ and $P_1 = \frac{V_1^2}{R} = \frac{V_1^2}{V^2} P$

4. (*a*) For the same voltage, $P \propto \frac{1}{R}$

5. (*b*) 6. (*b*) 7. (*c*) 8. (*b*)

VSA Very Short Answer Type Questions 2 Marks

9. **The wattage of a bulb is 24 W when it is connected to a 12 V battery. Calculate its effective wattage if it operates on a 6 V battery (Neglect the change in resistance due to unequal heating of the filament in the two cases).** [CBSE 2011]

Ans. Given: $P_1 = 24$ W, $V_1 = 12$ V, $P_2 = ?$, $V_2 = 6$ V

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

$$\frac{P_1}{P_2} = \frac{V_1^2}{V_2^2}$$

$$\Rightarrow \quad P_2 = \left(\frac{V_2}{V_1}\right) \times P_1$$

$$= \left(\frac{6}{12}\right)^2 \times 24 = \frac{1}{4} \times 24 = 6\ \text{W}$$

10. **For the same potential difference, out of the two, a room heater of 1000 W and an electric motor of 2 kW, which has a greater resistance?**

Ans. Power of room heater = 1000 W = P_1
Power of electric motor = 2 kW = 2000 W = P_2

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

For same potential

$$\frac{P_1}{P_2} = \frac{R_2}{R_1}$$

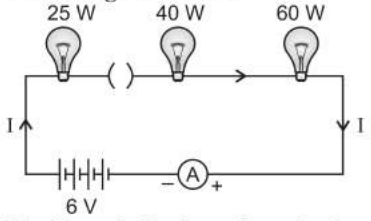
$$\therefore \quad \frac{R_2}{R_1} = \frac{P_1}{P_2}$$

$$= \frac{1000}{2000} = \frac{1}{2}$$

$$\Rightarrow \quad 2R_2 = R_1$$

So room heater has greater resistance.

11. **In the circuit given below:**



   (*a*) Would any bulb glow when plug key is in open position?
   (*b*) Write the order of brightness of the bulb when key is closed. Give reason.

Ans. (*a*) No bulb will glow when the plug key is in open position because no current will flow through the circuit.

(*b*) Power of bulb, $P = I^2R$
for the same current $P \propto R$
but for the same voltage $P \propto \frac{1}{R}$ or $R \propto \frac{1}{P}$
So, resistance order of all bulb is,
$R_{25} > R_{40} > R_{60}$
According to Jule's law of heating, $H \propto R$ (for the same current and time)
Hence, order of heating produced is
$H_{25} > H_{40} > H_{60}$
which is order of brightness of the bulbs when key is closed.

12. **The electric power consumed by a device may be calculated by either of the two expression $P = I^2R$ or $P = \frac{V^2}{R}$. The first expression indicates that it is directly proportional to R whereas the second expression indicates inverse proportionality. How can the seemingly different dependence of P on R in these expression be explained?**

Ans. (*a*) In series, the current in each resistor is same and constant. Therefore, $P = I^2R$ is used for series connection.

(*b*) In parallel, voltage across each resistance is same and constant. Therefore $P = \frac{V^2}{R}$ is used where resistors are connected in parallel combination.

SA Short Answer Type Questions 3 Marks

13. (*a*) It would cost a man Rs. 3.50 to buy 1.0 kWh of electrical energy from the Main Electricity Board. His generator has a maximum power of 2.0 kW. The generator produces energy at this maximum power for 3 hours. Calculate how much it would cost to buy the same amount of energy from the Main Electricity Board.

(*b*) A student boils water in an electric kettle for 20 minutes. Using the same mains supply he wants to reduce the boiling time of water. To do so should he increase or decrease the length of the heating element? Justify your answer.

[CBSE Sample Paper 2022]

Ans. (*a*) $E = P \times T$

So, $E = 3 \times 2 = 6$ kWh

Cost of buying electricity from the main electricity board = $6 \times 3.50 = ₹\ 21.0$

(*b*) To reduce the boiling time using the same mains supply, the rate of heat production should be large. We know that $P = \frac{V^2}{R}$. Since V is constant, R should be decreased. Since R is directly proportional to l so length of heating element should be decreased.

14. An electric motor rated 1100 W is connected to 220 V mains. Find:

(*i*) The current drawn from the mains.

(*ii*) Electric energy consumed if the motor is used for 5 hours daily for 6 days.

(*iii*) Total cost of energy consumed if the rate of one unit is ₹ 5. **[CBSE 2022]**

Ans. Given: Power, $P = 110$ W, $V = 220$ W

(*i*) Current drawn = $I = \frac{P}{V} = \frac{1100\ \text{W}}{220\ \text{V}} = 5$ A

(*ii*) $E = P \times t$

$= 1100\ \text{W} \times 5\ \text{h} \times 6\ \text{days}$

$= 33000\ \text{Wh} = 33\ \text{kWh}$

(*iii*) Cost of one commercial unit = ₹ 5

Energy consumed = 33 kWh = 33 unit

$= ₹\ 33 \times 5 = ₹\ 165$

LA Long Answer Type Questions 5 Marks

15. (*a*) Write two point of difference between electric energy and electric power.

(*b*) Out of 60 W and 40 W lamps, which one has higher electrical resistance when in use.

(*c*) What is the commercial unit of electric energy? Convert it into joules. **[CBSE 2015, 16]**

Ans. (*a*) Difference between electric energy and electric power:

Electrical energy	Electric power
(*i*) The work done or energy supplied by the source in maintaining the flow of electric current is called electrical energy. It appears in the form of heat given by $H = VIt = \frac{V^2 t}{R} = I^2RT$	(*i*) The time rate at which electric energy is consumed or dissipated by an electrical device is called electric power and is given by $P = VI = \frac{V^2}{R} = I^2R$
(*ii*) It is equal to the product of power and time $E = P \times t$	(*ii*) It equal to the rate of doing work by an energy source. $P = \frac{W}{t}$
(*iii*) Its SI unit is joule (J) $1\ \text{J} = 1\ \text{W} \times 1\text{s}$	(*iii*) Its SI unit is watt (W) $1\ \text{W} = 1\ \text{J s}^{-1}$

(*any two*)

(*b*) For the same applied voltage, $P \propto \frac{1}{R}$ or $R \propto \frac{1}{P}$

i.e. less the power of electrical device, higher is its electrical resistance.

Therefore, a 40 W lamp has higher electrical resistance when in use.

(*c*) Kilowatt hour – Commercial unit of electrical energy

$1\ \text{kWh} = 1000\ \text{Wh} = 1000\ \frac{J}{S} \times 3600\ \text{sec} = 3600000\ \text{J} = 3.6 \times 10^6\ \text{J}$

16. **(*a*) Define electric power. Express it in terms of potential difference V and resistance R.**
(*b*) An electrical fuse is rated at 2A. What is meant by this statement?
(*c*) An electric iron of 1 kW is operated at 220 V. Find which of the following fuses that respectively rated at 1 A, 3 A and 5 A can be used in it. **[CBSE 2014]**

Ans. (*a*) **Electric power:** It is the rate of doing work by an energy source or the rate at which the electrical energy is dissipated or consumed per unit time in the electric circuit is called electric power.

So, Power $P = \dfrac{\text{Work done (W)}}{\text{Time } (t)}$

$= \dfrac{\text{Electrical energy dissipated}}{\text{Time } (t)}$

$= \dfrac{VIt}{t} = VI = \dfrac{V^2}{R}$

(*b*) It means, the maximum current will flow through it is only 2 A. Fuse wire will melt if the current exceeds 2 A value through it.

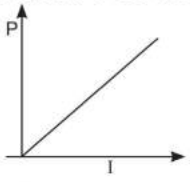
(*c*) Given: $P = 1$ kW $= 1000$ W, $V = 220$ V

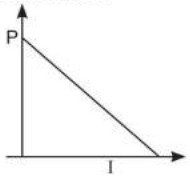
Current drawn, $I = \dfrac{P}{V} = \dfrac{1000}{220} = \dfrac{50}{11} = 4.54$ A

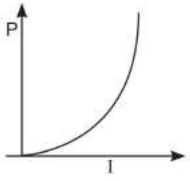
To run electric iron of 1 kW, rated fuse of 5 A should be used

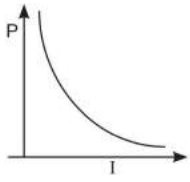
PRACTICE QUESTIONS

1. Which of the following graph correctly shows the variation in the dissipation of power '*P*' current varies with current '*I*' for the same resistance?

(*a*) 

(*b*) 

(*c*) 

(*d*) 

2. The watt is a
(*a*) Js^{-1}
(*b*) V-A
(*c*) both (*a*) and (*b*)
(*d*) neither (*a*) nor (*b*)

3. A 60 W electric lamp gives off energy in the form of light at a rate of 7.5 joule per second. What percentage of energy does the lamp transform into light energy?

4. An electric motor takes 5 A from 220 V line. Determine the power of a motor and the energy consumed in 2 hour.

5. (*i*) Define electric energy. In which form it appears?
(*ii*) What is the difference between kilowatt and kilowatt hour?

6. (*a*) An electric kettle of 2 kW is used for 2 h. Calculate the energy consumed in (*i*) Kilowatt hour (*ii*) Joules. **[CBSE 2022]**
(*b*) When a constant current is for a time of *t* seconds, how can you increase the heat produced to four times?

7. Calculate the total cost of running the following electrical devices in the month of September, if the rate of 1 unit of electricity is ₹ 6.00.
(*i*) Electric heater of 1000 W for 5 hours daily.
(*ii*) Electric refrigerator of 400 W for 10 hours daily.
[CBSE 2018(C)]

8. 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. **[CBSE 2019]**

INTEGRATED (MIXED) QUESTIONS

1. A boy records that 4000 joule of work is required to transfer 10 coulomb of charge between two points of a resistor of 50 Ω. The current passing through it is **(1 Mark)**
(*a*) 2 A (*b*) 4 A (*c*) 8 A (*d*) 16 A

2. The least resistance obtained by using 2 Ω, 4 Ω, 1 Ω and 100 Ω is **(1 Mark)**
(*a*) < 100 Ω (*b*) < 4 Ω
(*c*) < 1 Ω (*d*) > 2 Ω

3. Two wires of same length and area, made of two materials of resistivity ρ_1 and ρ_2 are connected in parallel to a source of potential *V*. The equivalent resistivity for the combination is **(1 Mark)**

(*a*) $\rho_1 + \rho_2$ (*b*) $\frac{2\rho_1\rho_2}{\rho_1+\rho_2}$

(*c*) $\frac{\rho_1+\rho_2}{2\rho_1\rho_2}$ (*d*) $\frac{\rho_1+\rho_2}{2}$

4. Two LED bulbs of 12 W and 6 W are connected in series. If the current through 12 W bulb is 0.06 A, the current through 6 W bulb will be

[CBSE 2023] **(1 Mark)**

(*a*) 0.04 A (*b*) 0.06 A (*c*) 0.08 A (*d*) 0.12 A

5. An electric iron of 1500 W, 200 V and a flash light of 500 W, 200 V are used in homes. The rating of fuse to be used should be [CBSE 2023] **(1 Mark)**

(*a*) 5 A (*b*) 10 A (*c*) 15 A (*d*) 20 A

6. Two resistors connected to 100 V supply in parallel draw 10 A current from the supply. If the power dissipation in one resistor is 600 W, find

(*i*) power dissipation in the other.

(*ii*) resistance of each. **(2 Marks)**

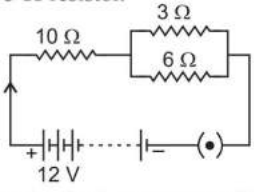
7. Three resistors 3 Ω, 6 Ω and 9 Ω are connected to a battery. In which of them power dissipation be maximum, if, they are all connected in (*i*) parallel (*ii*) series. Give reasons. **(2 Marks)**

8. Two lamps, one rated 100 W at 220 V and the other 60 W at 220 V, are connected in parallel to electric mains supply of 220 V. Draw a circuit diagram to show this arrangement and calculate the current drawn by the two lamps from the mains.

[CBSE 2021(C)] **(3 Marks)**

9. List in a tabular form three differences between a voltmeter and an ammeter. **(3 Marks)**

10. Consider the circuit shown in the diagram. Find the current in 3 Ω resistor. **(3 Marks)**



11. Name the physical quantity which is (*i*) same (*ii*) different in all the bulbs when three bulbs of :

(*a*) same wattage are connected in series.

(*b*) same wattage are connected in parallel.

(*c*) different wattage are connected in series.

(*d*) different wattage are connected in parallel. **(3 Marks)**

12. Two resistors with resistances 5 Ω and 10 Ω are to be connected to a battery of emf 6 V so as to obtain:

(*i*) minimum current (*ii*) maximum current

(*a*) How will you connect the resistances in each case ?

(*b*) Calculate the strength of the total current in the circuit in the two cases. [HOTS] **(3 Marks)**

13. (*a*) When a particle of charge 10 μC is brought from infinity to a point in the electric field, 10 mJ work is done by the external forces. What is the potential at that point?

(*b*) Draw an electric circuit to describe Ohm's law. Label the circuit components used to measure electric current and potential difference. **(3 Marks)**

14. (*a*) Write any three difference between the series and parallel combination of resistance.

(*b*) A set of 'n' identical resistors each resistance R are connected in series and the effective resistance is found to be 'X'. When these are connected in parallel, the effective resistance is found to be 'Y'. Find the ratio of X and Y. [HOTS] **(3 Marks)**

15. (*a*) Though same current flows through the electric line wires and the filament of bulb, yet only the filament glows. Why?

(*b*) The temperature of the filament of bulb is 2700 °C when it glows. Why does it not get burnt up at such high temperature?

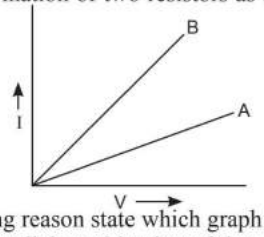
(*c*) The filament of an electric lamp, which draws a current of 0.25 A is used for four hours. Calculate the amount of charge flowing through the circuit.

(*d*) An electric iron is rated 2 kW at 220 V. Calculate the capacity of the fuse that should be used for the electric iron. **(5 Marks)**

16. (*a*) How is electric current related to potential difference across the terminals of a conductor? Draw the labelled circuit diagram to verify the relationship.

(*b*) Why should an ammeter have low resistance?

(*c*) Two V-I graph A and B for series and parallel combination of two resistors as shown.



Giving reason state which graph show (*a*) series (*b*) parallel combination of the resistors.

[CBSE 2023] **(5 Marks)**

17. (*a*) An electric iron consumes energy at a rate of 880 W when heating is at the maximum rate and 330 W when the heating is at the minimum. If the source voltage is 220 V, calculate the current and resistance in each case.

(*b*) What is heating effect of electric current?

(*c*) Find an expression for the amount of heat produced when a current passes through a resistor for some time. [CBSE 2023] **(5 Marks)**

ASSERTION AND REASON QUESTIONS

In the following Questions, the Assertion and Reason have been put forward. Read the statements carefully and choose the correct alternative from the following:

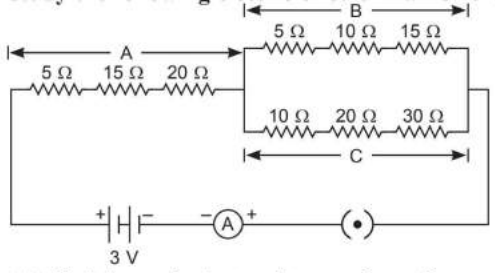
(*a*) Both the Assertion and the Reason are correct and the Reason is the correct explanation of the Assertion.
(*b*) The Assertion and the Reason are correct but the Reason is not the correct explanation of the Assertion.
(*c*) Assertion is true but the Reason is false.
(*d*) The statement of the Assertion is false but the Reason is true.

1. **Assertion:** The metals and alloys are good conductors of electricity.
   Reason: Bronze is an alloy of copper and tin and it is not a good conductor of electricity. **[CBSE 2020]**
2. **Assertion:** Alloys are commonly used in electrical heating devices like electric iron and heater.
   Reason: Resistivity of an alloy is generally higher than that of its constituent metals but the alloys have low melting points than their constituent metals. **[CBSE 2020]**
3. **Assertion:** At high temperatures, metals wires have a greater chance of short circuiting.
   Reason: Both resistance and resistivity of a material vary with temperature.
4. **Assertion:** Conductors allow the current to flow through themselves.
   Reason: They have free charge carriers.
5. **Assertion:** In an open circuit, the current passes from one terminal of the electric cell to another.
   Reason: Generally, the metal disc of a cell acts as a positive terminal.
6. **Assertion:** The statement of Ohm's law is $V = IR$
   Reason: $V = IR$ is the equation which defines resistance.
7. **Assertion:** Bending of wire decrease the resistance of electric wire.
   Reason: The resistance of a conductor depends on length, thickness, nature of material and temperature of the conductor.
8. **Assertion:** If a graph is plotted between potential difference and current a linear graph is obtained.
   Reason: Current is directly proportional to the potential difference. **[KVS]**
9. **Assertion:** A cell converts chemical energy into electrical energy.
   Reason: A cell maintains a potential difference across its terminals due to chemical reactions. **[KVS]**
10. **Assertion:** Thicker wires have smaller resistance and the thinner wires have greater resistance.
    Reason: Resistance is inversely proportional to the area of cross-section of wire.

CASE-BASED QUESTIONS

The following questions are source-based/case based question. Read the case carefully and answer the questions that follow.

1. **Study the following electric circuit in which the resistors are arranged in three arms A, B and C.**

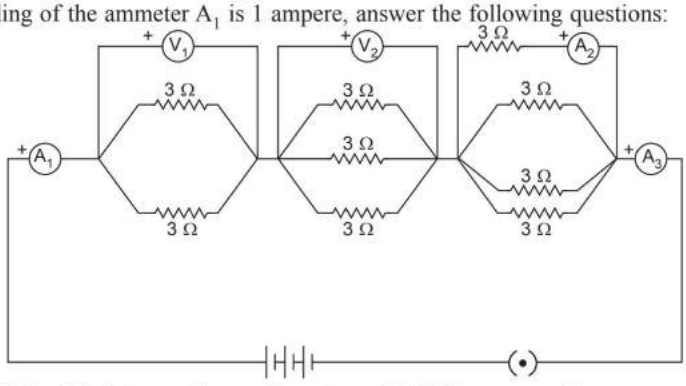


(*a*) Find the equivalent resistance of arm C.
(*b*) Calculate the equivalent resistance of the parallel combination of the arm B and C.
(*c*) Determine the current that flows through the ammeter.

Or

(*c*) Determine the current that flows in the ammeter when the arm B is withdrawn from the circuit. **[CBSE 2022]**

2. Consider the following electric circuit diagram in which nine identical resistors of 3 Ω each are connected as shown. If the reading of the ammeter A_1 is 1 ampere, answer the following questions:



(*a*) What is the relationship between the readings A_1 and A_3? Give reason for your answer.
(*b*) What is the relationship between the readings of A_2 and A_3?
(*c*) Determine the reading of the voltmeter V_1.

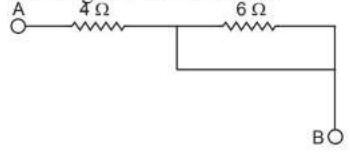
Or

(*c*) Find the total resistance of the circuit. **[CBSE 2023]**

3. Electricity requires an electric path to flow and there are many conducting materials used for this purpose. There are non-conducting materials which are used as insulation during working on live-lines.
Permanent indoor wiring is responsible for bringing electricity throughout your home. In house hold wiring, switches, holders and sockets should be fixed on wooden/sunmica boards and blocks. Nowadays, there are many semiconducting materials which are used to reduce the voltage and also drop the current flow. This will reduce our consumption of electrical energy.
(*a*) In which combination household wiring is done?
(*b*) Write down the properties of copper and aluminium and about their applications in electrical wiring.
(*c*) Write the equation relating power to voltage and current, for an electrical resistance. Also, describe what physical form this dissipated energy usually takes.

Or

(*c*) What is the effective resistance between A and B of the given circuit below?



4. Resistivity is a characteristic property of the material. It measures the resistance of a given dimensions of a specific material to electrical conduction. The resistivity is a figure that enables comparisons of the way in which different materials allow or resist current flow. It is essential in many material applications including resistors in electrical circuits, dielectrics, resistive heating and superconducting. The materials which have high resistivity are poor conductors of electricity.
Materials are put into different categories according to their level or resistivity. The material's resistivity, in ohm-metre, measured at room temperature.
The temperature often has a significant effect on resistivity. For example, in metal conductors, increased temperature causes the ions to vibrate more, which hinders the flow of electrons, causing resistivity to increase.
(*a*) Arrange the following material in increasing order of resistivity.
Conductor, alloy, insulator and semiconductor.
(*b*) The following table given below shows the resistivity of three samples. Analyse the table and find which one of these is the best conductor and best insulator?

Sample	Resistivity (Ωm)
X	3×10^{-8}
Y	11.1×10^{-6}
Z	$18 \times 10^{+14}$

(*c*) How resistance of the conductor is related to its temperature? Show it graphically.

Or

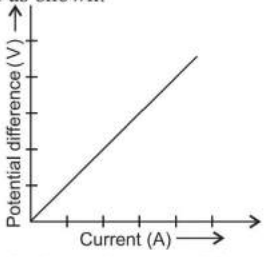
(*c*) If we take a lot of copper metal of resistivity 1.62×10^{-8} Ωm and form a cube of side 1 m and one square metre area of cross-section, then what will be its resistance?

5. In 1827, a German physicist Georg Simon Ohm (1787-1854) gave the relationship between the current (*I*), flowing in a metallic wire and the potential difference

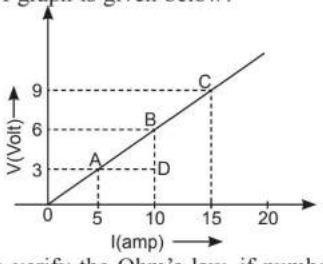
(V) across its terminals. It is called Ohm's Law. It states that "the potential difference (V), across the ends of a given metallic wire (nichrome) in an electric circuit is directly proportional to the current (I) flowing through it". Temperature (T) remains constant.

$$V \propto I$$
$$V = IR$$

Where, R is a constant for the given metallic wire at a given temperature and is called its resistance. V-I graph is a straight line passing through the origin of the graph as shown:

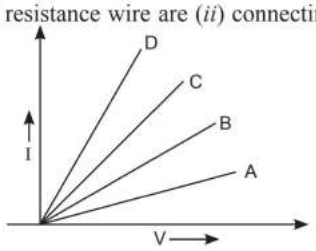


(a) What is the resistance of the conductor whose V-I graph is given below?



(b) To verify the Ohm's law, if number of cells in series in the same circuit increases, what would you observe in the ammeter and voltmeter readings?

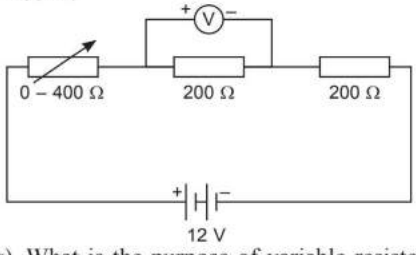
(c) The I-V graph for four conductors A, B, C and D having resistance RA, RB, RC and RD respectively are shown here. If the dimensions of all the conductors are identical but their materials are different, which one would you use as (i) resistance wire are (ii) connecting wire?



Or

(c) A lamp draws a current of 0.5 A when it is connected to a 60 V source. What is the resistance of filament of the bulb?

6. The circuit below consists of a variable resistor connected in series with two 200 Ω resistors. The variable resistor can be adjusted to any value between 0–400 Ω.



(a) What is the purpose of variable resistor in the circuit?

(b) The maximum possible current in the circuit is 0.03 A. Calculate the minimum possible current.

(c) As the resistance of the variable resistor is changed, what is the (i) smallest and (ii) maximum possible reading on the voltmeter?

Or

(c) In which case, the power dissipation across 200 Ω resistor will be more:
When variable resistor is at maximum value or at minimum value? Justify it.

7. Observe the tables given below and answer the following questions.

Table – A Combination of resistor

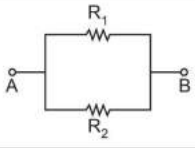
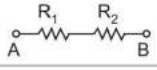
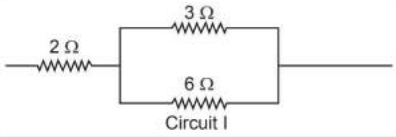
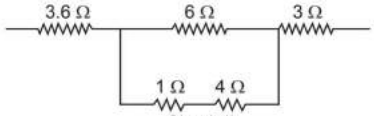
Combination	Circuit	Equivalent resistance
Parallel		$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2}$
Series		$R_{eq} = R_1 + R_2$

Table – B Combination of resistance

Student	Circuit	Equivalent resistance
A	 Circuit I	4 Ω
B	 Circuit II	3.4 Ω

(*a*) Which student measured the wrong equivalent resistance in table B?

(*b*) Which physical quantity that will remain same across the combination of 3 Ω and 6 Ω in circuit-I and combination of 6 Ω along with the combination of 1 Ω and 4 Ω in circuit-II.

(*c*) If both students connected their respective circuits through an external source, how can they measure the current in the circuit?

Or

(*c*) In an electrical circuit, two resistor of 2 Ω and 4 Ω respectively are connected in series to a 6 V battery. Calculate what amount of heat will be dissipated by the 4 Ω resistor in 5 seconds.

8. Study the table related to combination of resistors and answer the questions that follow on the basis of your understanding and the related studied concepts.

Circuits consisting of just one battery and one load resistance are very simple to analyse, but they are not often found in practical applications. Usually, we find circuits where more than two components are connected together in different combinations. These combinations of resistors put the limit on the current that flow through the circuit. After performing the experiments using two different types of circuit arrangements, the following observations were made by them and find the resistance using Ohm's law.

Resistor Used	Number of Observation	Voltmeter reading in Volt *(V)*	Ammeter reading in ampere *(A)*	$R = \frac{V}{I}$ (in ohm)
R_1	(*a*) (*b*)	0.01 0.02	0.01 0.02	1.0 1.0
R_2	(*a*) (*b*)	0.06 0.08	0.03 0.04	2.0 2.0
Ist combination of R_1 *and* R_2	(*a*) (*b*)	0.03 0.06	0.01 0.02	3.0 3.0
IInd combination of R_1 *and* R_2	(*a*) (*b*)	0.03 0.06	0.045 0.09	0.66 0.66

(*a*) From observation, which combination represents series and parallel combination of the resistor R_1 and R_2?

(*b*) You will plot *V* vs *I* for each of the four circuits on one graph. What value should each slope have? (Note: *I* on X-axis and *V* on Y-axis)

(*c*) Note that the measured currents across each resistor in parallel circuit were not the same. Which resistor had the larger current going through it? Why?

Or

(*c*) Do you think the bulbs in the parallel circuit or the series circuit will burn brighter?

NCERT ZONE

NCERT INTEXT QUESTIONS

Page 172

1. What does an electric circuit mean?

Ans. Electric circuit is a continuous and closed path made of conducting wires, through which the electric current flows. It comprises a cell, ammeter, voltmeter, plug key, etc.

2. Define the unit of current.

Ans. SI unit of electric current is ampere (A).
Ampere is the flow of electric charges through a surface at the rate of one coulomb per second, i.e. if 1 coulomb of electric charge flows through a cross-section of wire for 1 second, then it would be equal to 1 ampere.

So, 1 ampere $= \frac{1\text{ C}}{1\text{ s}}$ i.e. $1\text{A} = 1\text{ Cs}^{-1}$

3. Calculate the number of electrons constituting one coulomb of charge.

Ans. Given $q = 1$ C, $e = 1.6 \times 10^{-19}$ C, $n = ?$, $q = ne$

$$1\text{ C} = n \times 1.6 \times 10^{-19}\text{ C}$$

$$n = \frac{1}{(1.6 \times 10^{-19})} = 6.25 \times 10^{18}\text{ electrons}$$

Page 174

1. Name a device that helps to maintain a potential difference across a conductor. [CBSE 2014]

Ans. Cell or battery eliminator.

2. What is meant by saying that the potential difference between two points is 1 V?

Ans. As we know that $V = \frac{W}{q}$

Thus, the potential difference between two points is one volt when one joule of work is done to carry a charge of one coulomb between the two points in the electric field.

3. How much energy is given to each coulomb of charge passing through a 6 V battery?

Ans. $q = 1$ C; $V = 6$ V,

$$V = \frac{W}{q} \quad \Rightarrow \quad W = q \times V$$

So, Work done $= 1\text{ C} \times 6\text{ V} = 6\text{ J}$
As, Energy = Work done
$\Rightarrow$ Energy $= 6$ J

Page 181

1. On what factors does the resistance of a conductor depend? [DoE]

Ans. Resistance of a conductor depends upon:
(*i*) Resistivity of the material.
(*ii*) Length of the conductor.
(*iii*) Cross-sectional area of the conductor.
(*iv*) Temperature of the conductor.

2. Will current flow more easily through a thick wire or thin wire of the same material, when connected to the same source? Why?

Ans. The current flows more easily through a thick wire than through a thin wire because the resistance of thick wire is less than that of a thin wire as $R \propto 1/A$.

3. Let the resistance of an electrical component remains constant while the potential difference across the two ends of the component decreases to half of its former value. What change will occur in the current through it?

Ans. As we know that

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

if $$V' = \frac{V}{2}$$

$$\Rightarrow \quad I' = \frac{V'}{R} = \frac{V}{2R} = \frac{I}{2}$$

Hence, the current through it also becomes half of its previous value.

4. Why are the coils of electric toasters and electric irons made of an alloy rather than a pure metal?

Ans. The coils of electric toaster and electric iron are made of an alloy rather than a pure metal because of the following reasons:
(*i*) The resistivity of an alloy is higher than that of a pure metal.
(*ii*) It has high melting point and does not oxidise.

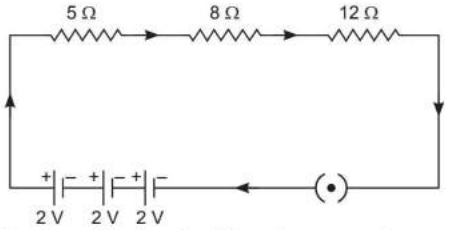
5. Use the data in Table 11.2 of NCERT book to answer the following:
(*a*) Which among iron and mercury is a better conductor?
(*b*) Which material is the best conductor?

Ans. (*a*) Iron because its resistivity is less than mercury.
(*b*) Silver is the best conductor as it has the least resistivity.

Page 185

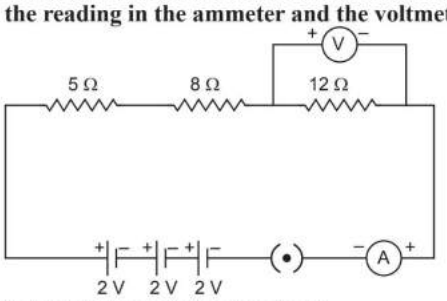
1. Draw a schematic diagram of a circuit consisting of a battery of three cells of 2 V each, a 5 Ω resistor, a 8 Ω resistor and a 12 Ω resistor and a plug key, all connected in series.

Ans.



2. Redraw the circuit of the above question, putting in an ammeter to measure the current through the resistors and a voltmeter to measure the potential difference across the 12 Ω resistor. What would be the reading in the ammeter and the voltmeter?

Ans.



Total resistance of the circuit = R

Since all the three resistors are connected in series, so, the equivalent resistance R is equal to the sum of all resistance i.e.,

$R = R_1 + R_2 + R_3$

$R = 5\ \Omega + 8\ \Omega + 12\ \Omega = 25\ \Omega$

$V = 2\ \text{V} + 2\ \text{V} + 2\ \text{V} = 6\ \text{V}$

$V = IR$

$\Rightarrow \quad I = \dfrac{V}{R} = \dfrac{6}{25} = 0.24\ \text{A}$

The reading of voltmenter across 12 Ω is

$V' = IR' = 0.24 \times 12 = 2.88\ \text{V}$

Page 188

1. Judge the equivalent resistance when the following are connected in parallel.

(*a*) 1 Ω and 10^6 Ω (*b*) 1 Ω and, 10^3 Ω, and, 10^6 Ω.

Ans. Equivalent resistance in parallel combination of resistors is always less than the least resistance of any resistor in the circuit.

Hence, in both the given cases, the equivalent resistance is less than 1 Ω.

2. An electric lamp of 100 Ω, a toaster of resistance 50 Ω, and a water filter of resistance 500 Ω are connected in parallel to a 220 V source. What is the resistance of an electric iron connected to the same source that takes as much current as all three appliances, and what is the current flows through it?

Ans. $R_1 = 100\ \Omega$, $R_2 = 50\ \Omega$, $R_3 = 500\ \Omega$

All the applications are connected in parallel, so

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

$$= \frac{1}{100} + \frac{1}{50} + \frac{1}{500}$$

$$= \frac{5 + 10 + 1}{500} = \frac{16}{500}$$

$$R = \frac{500}{16} = \frac{125}{4}\ \Omega$$

Current through all the appliances

$$I = \frac{V}{R} = \frac{220}{125/4} = \frac{220 \times 4}{125}$$

$= 7.04$ A

Now if only electric iron is connected to the same source such that it takes as much current as all three appliances, *i.e.* $I = 7.04$ A, its resistance should be equal to $\dfrac{125}{4}\ \Omega$, i.e. 31.25 Ω.

3. What are the advantages of connecting electrical devices in parallel with the battery instead of connecting them in series ?

Ans. Advantages of connecting electrical devices in parallel:

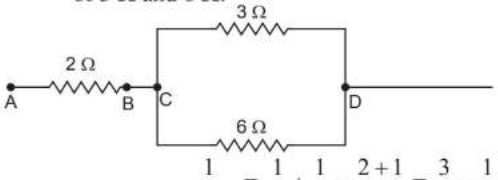
(*i*) When the appliances are connected in parallel with the battery, each appliance gets the same potential difference as that of battery which is not possible in series connection.

(*ii*) Each appliance has different resistances and requires different currents to operate properly. This is possible only in parallel connection, as in series connection, same current flows through all devices, irrespective of their resistances.

(*iii*) If one appliance fails to work, other will continue to work property. If they are connected in parallel.

4. How can three resistors of resistances 2 Ω, 3 Ω and 6 Ω be connected to give a total resistance of (*a*) 4 Ω (*b*) 1 Ω?

Ans. (*a*) In order to get 4 Ω, resistance 2 Ω should be connected in series with the parallel combination of 3 Ω and 6 Ω.



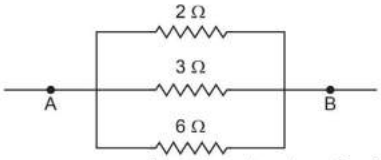
$$\frac{1}{R_{CD}} = \frac{1}{3} + \frac{1}{6} = \frac{2+1}{6} = \frac{3}{6} = \frac{1}{2}$$

$R_{CD} = 2\ \Omega$, $R_{AB} = 2\ \Omega$

$\Rightarrow \quad R_{AD} = R_{AB} + R_{CD} = 2\ \Omega + 2\ \Omega$

$= 4\ \Omega$

(*b*) In order to get 1 Ω, all three resistors should be connected in parallel as



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

5. What is (*a*) the highest (*b*) the lowest total resistance that can be secured by combination of four coils of resistances 4 Ω, 8 Ω, 12 Ω, 24 Ω?

Ans. (*a*) The highest resistance is secured by combining all four coils of resistance in series.

$R_s = 4\ \Omega + 8\ \Omega + 12\ \Omega + 24\ \Omega = 48\ \Omega$

(*b*) The lowest resistance is secured by combining all four coils of resistance in parallel.

$$\frac{1}{R_P} = \frac{1}{4} + \frac{1}{8} + \frac{1}{12} + \frac{1}{24}$$
$$= \frac{6+3+2+1}{24} = \frac{12}{24}$$
$$R_P = 2\ \Omega$$

Page 190

1. Why does the cord of an electric heater not glow while the heating element does?

Ans. The cord of an electric heater is made up of metallic wire such as copper or aluminium which has low resistance while the heating element is made up of an alloy which has more resistance than its constituent metals. Also heat produced '*H*' is

$$H = I^2Rt$$

Thus, for the same current $H \propto R$, more heat is produced by heating element as it has more resistance, and it glows.

2. Compute the heat generated while transferring 96000 coulomb of charge in one hour through a potential difference of 50 V.

Ans. Given $q = 96000$ C, $V = 50$ V, $t = 1$ h

$H = I^2Rt = VIt = Vq = 50 \times 96000 = 48 \times 10^5$ J

3. An electric iron of resistance 20 Ω takes a current of 5 A. Calculate the heat developed in 30 s.

Ans. Given $R = 20\ \Omega$, $I = 5$ A, $t = 30$ s

$H = I^2Rt = (5)^2 \times 20 \times 30 = 15000$ J $= 1.5 \times 10^4$ J

Page 192

1. What determines the rate at which energy is delivered by a current?

Ans. Electric power determines the rate at which energy is delivered by a current.

2. An electric motor takes 5 A from a 220 V line. Determine the power of the motor and the energy consumed in 2 h.

Ans. Given $I = 5$ A, $V = 220$ V, $t = 2$ h

Power, $P = VI = 220 \times 5$
$= 1100$ W

Energy consumed,
$E = P \times t = 1100 \times 2 \times 60 \times 60$
$= 1100 \times 7200$
$= 7.92 \times 10^6$ J

NCERT EXERCISES

1. A piece of wire of resistance *R* is cut into five equal parts. These parts are then connected in parallel. If the equivalent resistance of this combination is *R′*, then the ratio *R*/*R′* is

(*a*) $\frac{1}{25}$ (*b*) $\frac{1}{5}$ (*c*) 5 (*d*) 25

Ans. (*d*) On cutting, there will be 5 equal resistors of $\frac{R}{5}\ \Omega$ each. When they are connected in parallel the equivalent value will be

$$\frac{1}{R'} = \frac{1}{R/5} + \frac{1}{R/5} + \frac{1}{R/5} + \frac{1}{R/5} + \frac{1}{R/5}$$
$$= \frac{25}{R}$$

i.e. $R' = \frac{R}{25}\ \Omega. \Rightarrow \frac{R}{R'} = \frac{R}{R/25} = 25.$

2. Which of the following terms does not represent electrical power in a circuit?

(*a*) I^2R (*b*) IR^2 (*c*) VI (*d*) V^2/R

Ans. (*b*) $P = \frac{V^2}{R} = I^2R = VI$. Hence, option (*b*) does not represent electrical power.

3. An electric bulb is rated 220 V and 100 W. When it is operated on 110 V, the power consumed will be

(*a*) 100 W (*b*) 75 W
(*c*) 50 W (*d*) 25 W

Ans. (*d*) R of bulb $= \frac{220^2}{100}$.

Power consumed at 110 V $= \frac{V^2}{R} = \frac{110^2}{R}$

$= \frac{110^2}{220^2} \times 100 = 25$ W.

4. Two conducting wires of the same material and of equal lengths and diameters are first connected in series and then parallel in a circuit across the same potential difference. The ratio of heat produced in series and parallel combinations would be

(*a*) 1 : 2 (*b*) 2 : 1 (*c*) 1 : 4 (*d*) 4 : 1

Ans. (*c*) Resistors are equal. So, power in series

$(P_s) = \frac{V^2}{2R}$ ..... $(R_s = R + R = 2R)$

Power in parallel $(P_P) = \dfrac{V^2}{(R/2)} = \dfrac{2V^2}{R}$ .....

$\left[\dfrac{1}{R_p} = \dfrac{1}{R} + \dfrac{1}{R} = \dfrac{2}{R} \therefore R_P = R/2\right]$

So, $P_S : P_P = \dfrac{1}{2} : 2 = 1 : 4.$

5. How is a voltmeter connected in the circuit to measure the potential difference between two points?

Ans. A voltmeter is connected in parallel to a circuit with its +ve terminal to the point at higher potential and –ve terminal to the point at lower potential.

6. A copper wire has diameter 0.5 mm and resistivity of 1.6×10^{-8} Ωm. What will be the length of this wire to make its resistance 10 Ω? How much does the resistance change if the diameter is doubled?

Ans. $d = 0.5$ mm, $r = \dfrac{0.5}{2} \times 10^{-3}$ m,

$\rho = 1.6 \times 10^{-8}$ Ω m, $R = 10$ Ω

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

we get $l = \dfrac{R\pi r^2}{\rho}$ ..... $(A = \pi r^2)$

$= \dfrac{10 \times 3.14}{1.6 \times 10^{-8}} \times \left(\dfrac{0.5}{2} \times 10^{-3}\right)^2$

$= 122.6 \text{ m} \approx 123 \text{ m}.$

If the diameter is doubled radius of copper wire is also doubled.

$\therefore \quad \dfrac{A_1}{A_2} = \dfrac{\pi r^2}{\pi (2r)^2} = \dfrac{1}{4}$

So, $A_2 = 4A_1$

For the same length and same material wire,

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

we get, $\dfrac{R_2}{R_1} = \dfrac{A_1}{A_2}$

$= \dfrac{A_1}{4A_1} = \dfrac{1}{4}$

$\therefore \quad R_2 = \dfrac{1}{4} R_1$

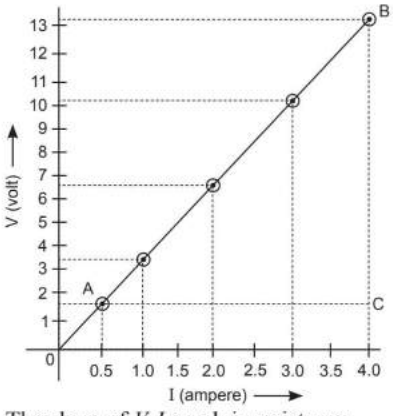
Hence, the resistance becomes one-fourth of the original one.

7. The values of the current *I* flowing in a given resistor for the corresponding values of potential difference V across the resistor are given below:

***I* (amperes)**	**0.5**	**1.0**	**2.0**	**3.0**	**4.0**
***V* (volts)**	**1.6**	**3.4**	**6.7**	**10.2**	**13.2**

Plot a graph between *V* and *I* and calculate the resistance of that resistor.

Ans.



The slope of *V*-*I* graph is resistance.

So, resistance, $R = \dfrac{\text{Change in } V}{\text{Change in } I} = \dfrac{BC}{AC}$

$= \dfrac{13.2 - 1.6}{4 - 0.5}$

$= \dfrac{11.6}{3.5} = 3.314\ \Omega.$

8. When a 12 V battery is connected across an unknown resistor, there is a current of 2.5 mA in the circuit. Find the value of the resistance of the resistor.

Ans. $V = IR \Rightarrow R = \dfrac{V}{I}$

$\Rightarrow \quad R = \dfrac{12}{2.5 \times 10^{-3}} = 4800\ \Omega = 4.8\ \text{k}\Omega.$

9. A battery of 9 V is connected in series with resistors of 0.2 Ω, 0.3 Ω, 0.4 Ω, 0.5 Ω and 12 Ω, respectively. How much current would flow through the 12 Ω resistor?

Ans. $R_s = 0.2 + 0.3 + 0.4 + 0.5 + 12 = 13.4\ \Omega$, $V = 9$ V,

Current drawn, $I = \dfrac{V}{R} = \dfrac{9}{13.4}\ \text{A} = 0.67\ \text{A}.$

Since all the resistors are in series, the same current, i.e. 0.67 A flows through the 12 Ω resistor.

10. How many 176 Ω resistors (in parallel) are required to carry 5 A on a 220 V line?

Ans. When N resistors each R Ω are in parallel,

$R_P = \dfrac{R}{N}.$

Current drawn from cell,

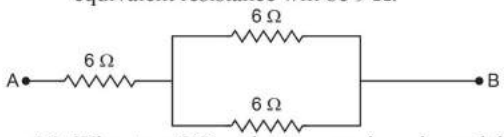
$I = \dfrac{V}{R_P} = \dfrac{VN}{R}$

$\therefore \quad N = \dfrac{IR}{V} = \dfrac{5 \times 176}{220} = 4.$

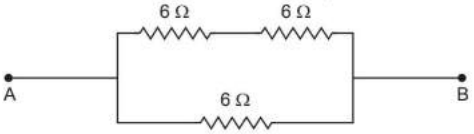
11. Show how you would connect three resistors, each of resistance 6 Ω, so that the combination has a resistance of

(*i*) 9 Ω, (*ii*) 4 Ω.

Ans. (*i*) When two 6 Ω resistances are in parallel and the third is in series combination to this, the equivalent resistance will be 9 Ω.



(*ii*) When two 6 Ω resistances are in series and the third is in parallel to them, then it will be 4 Ω.



12. Several electric bulbs designed to be used on a 220 V electric supply line, are rated 10 W. How many lamps can be connected in parallel with each other across the two wires of 220 V line if the maximum allowable current is 5 A?

Ans. N bulbs of power P each connected in parallel will make the total power of NP, therefore, using

$$I = \frac{NP}{V}$$

Current drawn,

$$I = 5 = \frac{N \times 10}{220}$$

$$\therefore \quad N = \frac{5 \times 220}{10} = 110$$

13. A hot plate of an electric oven connected to a 220 V line has two resistance coils *A* and *B*, each of 24 Ω resistance, which may be used separately, in series, or in parallel. What are the currents in the three cases?

Ans. When used individually,

$$I = \frac{220}{24} = 9.16 \text{ A in both of them.}$$

When used in series,

$$R_s = 24 + 24 = 48\ \Omega,$$

$$\Rightarrow \quad I_s = \frac{220}{48} \text{ A} = 4.58 \text{ A}$$

When used in parallel,

$$R_P = \frac{24 \times 24}{48} = 12\ \Omega$$

$$\Rightarrow \quad I_P = \frac{220}{12} \text{ A} = 18.3 \text{ A}.$$

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

(*i*) a 6 V battery in series with 1 Ω and 2 Ω resistors, and

(*ii*) a 4 V battery in parallel with 12 Ω and 2 Ω resistors.

Ans. (*i*) $I = \frac{6}{1+2} = 2 \text{ A}$

Since current flowing is same in both resistors, power used in 2 Ω resistor

$P_1 = I^2R = (2)^2 \times 2 = 8$ W.

(*ii*) Since both 12 Ω and 2 Ω are in parallel to the 4 V source,

Power used in 2 Ω resistor

$$P_2 = \frac{V^2}{R} = \frac{4^2}{2} = \frac{16}{2} = 8 \text{ W}.$$

Comparison between the power used in both cases $= \frac{P_1}{P_2} = \frac{8 \text{ W}}{8 \text{ W}} = 1.$

15. Two lamps, one rated 100 W at 220 V, and the other 60 W at 220 V, are connected in parallel to electric mains supply. What current is drawn from the line if the supply voltage is 220 V?

Ans. $R_{100} = \frac{220^2}{100}$, $R_{60} = \frac{220^2}{60}$.

$$\text{Current drawn by 100 W bulb} = \frac{220}{R_{100}} = \frac{100}{220} \text{ A}$$

$$= 0.45 \text{ A}.$$

$$\text{Current drawn by 60 W bulb} = \frac{220}{R_{60}}$$

$$= \frac{60}{220} \text{ A} = 0.27 \text{ A}.$$

Total current drawn from the line

$= 0.45 \text{ A} + 0.27 \text{ A} = 0.72 \text{ A}.$

16. Which uses more energy, a 250 W TV set in 1 hr, or a 1200 W toaster in 10 minutes?

Ans. Energy consumed by 250 W TV set in 1 h

$= 250 \times 1 = 250$ Wh.

Energy consumed by 1200 W toaster in 10 min

$$= 1200 \times \frac{10}{60} = 200 \text{ Wh}.$$

$\therefore$ Energy consumed by TV set is more than the energy consumed by toaster in the given timings.

17. An electric heater of resistance 8 Ω draws 15 A from the service mains 2 hours. Calculate the rate at which heat is developed in the heater.

Ans. $R = 8\ \Omega$, $I = 15$ A, $t = 2$h

$$\text{Rate of heat developed} = \frac{H}{t} = \frac{I^2Rt}{t} = 15^2 \times 8$$

$$= 225 \times 8 = 1800 \text{ Js}^{-1}.$$

18. Explain the following.

(*a*) Why is the tungsten used almost exclusively for filament of electric lamps?

(*b*) Why are the conductors of electric heating devices, such as bread-toasters and electric irons, made of an alloy rather than a pure metal?

(c) Why is the series arrangement not used for domestic circuits?

(d) How does the resistance of a wire vary with its area of cross-section?

(e) Why are copper and aluminium wires usually employed for electricity transmission?

Ans. (a) It has high melting point and emits light at a high temperature.

(b) It has more resistivity and less temperature coefficient of resistance.

(c) (i) All appliances do not get same potential in series arrangement.

(ii) All appliances cannot be individually operated.

(d) $R \propto \dfrac{1}{\text{Area of cross - section}}$

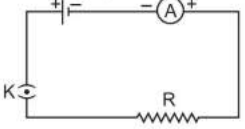
(e) They are very good conductors of electricity.

SELECT NCERT EXEMPLAR PROBLEMS

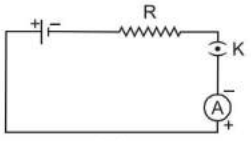
1. A cell, a resistor, a key and an ammeter are arranged as shown in the circuit diagrams. The current recorded in the ammeter will be

(a) maximum in (i) (b) maximum in (ii)

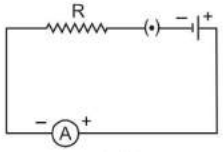
(c) maximum in (iii) (d) same in all the cases



(i)



(ii)



(iii)

Ans. (d) Ammeter is always connected in series with in the circuit. The reading is independent from its location.

2. A current of 1 A is drawn by a filament of an electric bulb. Number of electrons passing through a cross-section of the filament in 16 seconds would be roughly

(a) 10^{20} (b) 10^{16} (c) 10^{18} (d) 10^{23}

Ans. (a) $Q = ne$ and $Q = It$

$\therefore \quad ne = It$

or $\quad n = \dfrac{It}{e} = \dfrac{1 \times 16}{1.6 \times 10^{-19}} = 10^{20}$ electrons

3. A cylindrical conductor of length *l* and uniform area of cross-section A has resistance R. Another conductor of length 2*l* and resistance R of the same material has area of cross-section

(a) A/2 (b) 3A/2

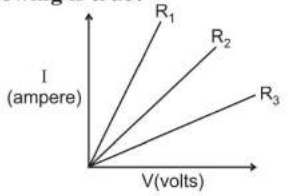
(c) 2A (d) 3A

Ans. (c) Since $R \propto \dfrac{l}{A}$ So, $\dfrac{R_1}{R_2} = \dfrac{l_1}{l_2} \cdot \dfrac{A_2}{A_1}$

$\Rightarrow \quad \dfrac{l}{2l} \times \dfrac{A_2}{A} = \dfrac{R}{R} = 1$

$\Rightarrow \quad A_2 = 2A$

4. A student carries out an experiment and plots the V-I graph of three samples of nichrome wire with resistances R_1, R_2 and R_3 respectively. Which of the following is true?



(a) $R_1 = R_2 = R_3$ (b) $R_1 > R_2 > R_3$

(c) $R_3 > R_2 > R_1$ (d) $R_2 > R_3 > R_1$

Ans. (c) Current is inversely proportional to the resistance for the same potential. So higher resistance would allow less current to pass through its which is shown by R_3, as $I_3 < I_2 < I_1$.

$\therefore \quad R_3 > R_2 > R_1$

5. If the current I through a resistor is increased by 100 % (assume that temperature remains unchanged), the increase in power dissipated will be

(a) 100 % (b) 200 %

(c) 300 % (d) 400 %

Ans. (c) Since, $P \propto I^2$

So $\dfrac{P_2}{P_1} = \left(\dfrac{I_2}{I_1}\right)^2 = \left(\dfrac{2I}{I}\right)^2 = 4$

$\Rightarrow \quad P_2 = 4P_1$

$\therefore$ % increase in power $= \dfrac{P_2 - P_1}{P_1} \times 100$

$= \dfrac{4P - P}{P} \times 100 = 300\%$

6. The resistivity does not change if

(a) the material is changed

(b) the temperature is changed

(c) the shape of the resistor is changed

(d) both material and temperature are changed

Ans. (c) The resistivity does not change if the shape of resistor is changed because nature of material will remain same.

7. In an electrical circuit two resistors of 2 Ω and 4 Ω respectively are connected in series to a 6 V battery. The heat dissipated by the 4 Ω resistor in 5 s will be

(*a*) 5 J (*b*) 10 J
(*c*) 20 J (*d*) 30 J

Ans. (*c*) Total resistance of the combination

$R_s = 2 + 4 = 6\ \Omega$

Current, $I = \dfrac{V}{R_s} = \dfrac{6}{6} = 1$

Heat dissipation in 4 Ω resistor,

$H = I^2Rt = 1^2 \times 4 \times 5 = 20$ J

8. Electrical resistivity of a given metallic wire depends upon

(*a*) its length (*b*) its thickness
(*c*) its shape (*d*) nature of the material

Ans. (*d*)

9. What is the minimum resistance which can be made using five resistors each of 1/5 Ω?

(*a*) 1/5 Ω (*b*) 1/25 Ω
(*c*) 1/10 Ω (*d*) 25 Ω

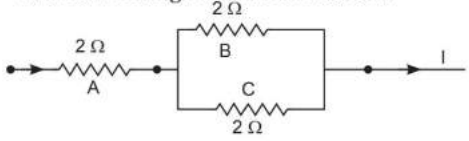
Ans. (*b*)

10. In an electrical circuit three incandescent bulbs A, B and C of rating 40 W, 60 W and 100 W respectively are connected in parallel to an electric source. Which of the following is likely to happen regarding their brightness?

(*a*) Brightness of all the bulbs will be the same
(*b*) Brightness of bulb A will the maximum
(*c*) Brightness of bulb B will be more than that of A
(*d*) Brightness of bulb C will be less than that of B

Ans. (*c*)

11. Three 2 Ω resistors, *A*, *B* and *C* are connected as shown in figure. Each of them dissipates energy and can withstand a maximum power of 18 W without melting. Find the maximum current that can flow through the three resistors.



Ans. Here, $P = 18$ W

Since *A* is in series with the parallel combination of *B* and *C*. So, it carries maximum current.

Using $P = I^2R$, we get

$$I^2 = \frac{P}{R} = \frac{18}{2} = 9$$

$\Rightarrow \quad I = 3$ A.

Let I_B and I_C be the current flowing through *B* and *C* respectively. As they are in parallel, potential difference across them will be same so

$$I_BR_B = I_CR_C$$

or $$\frac{I_B}{I_C} = \frac{R_C}{R_B} = \frac{2}{2} = 1$$

$\Rightarrow \quad I_B = I_C$

But $I_B + I_C = I = 3$ A

$\therefore \quad 2I_B = 3$ or $I_B = \dfrac{3}{2} = 1.5$ A

and $I_B = I_C = 1.5$ A.

12. Should the resistance of an ammeter be low or high? Give reason.

Ans. The resistance of an ammeter should be low so that it will not disturb the magnitude of current of the circuit when connected in series in a circuit.

13. How does use of a fuse wire protect electrical appliances?

Ans. The fuse wire is always connected in series with the live wire or electrical devices. If the flow of current exceeds the specified preset value due to some reason, the heat produced melts it and disconnects the circuit or the device from the mains. In this way, fuse wire protects the electrical appliances.

14. What is electrical resistivity? In a series electrical circuit comprising a resistor made up of a metallic wire, the ammeter reads 5 A. The reading of the ammeter decreases to half when the length of the wire is doubled. Why?

Ans. The resistance offered by a metallic wire of unit length and unit cross-sectional area is called electrical resistivity.

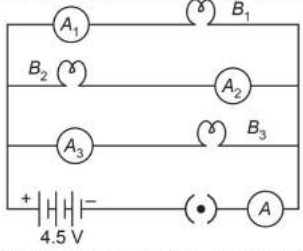
We know that

$$R = \rho\frac{l}{A} \text{ and } V = IR$$

So, $R \propto l$ and $I \propto \dfrac{1}{R}$, (V is constant)

Hence, when the length of wire is doubled the resistance becomes double and current decreases to half.

15. B_1, B_2 and B_3 are three identical bulbs connected as shown in figure. When all the three bulbs glow, a current of 3A is recorded by the ammeter *A*.



(*a*) What happens to the glow of the other two bulbs when the bulb B_1 gets fused?

(*b*) What happens to the reading of A_1, A_2, A_3 and *A* when the bulb B_2 gets fused?

(*c*) How much power is dissipated in the circuit when all the three bulbs glow together?

Ans. (*a*) Since B_1, B_2 and B_3 are in parallel, the potential difference across each of them will remain same. So when the bulb B_1 gets fused, B_2 and B_3 have the same potential and continues with the same energy dissipated per second, i.e. they will glow as they were glowing before.

(*b*) Resistance of the parallel combination when all the three bulbs are glowing

$$\frac{1}{R_P} = \frac{1}{R} + \frac{1}{R} + \frac{1}{R} = \frac{3}{R}$$

$$R_P = \frac{R}{3}$$

Ammeter '*A*' reads 3 A current

So, $V = IR_P$

$$4.5 = 3 \times \frac{R}{3} \quad \Rightarrow \quad R = 4.5\ \Omega$$

So, resistance of each bulb = 4.5 Ω.

Now when bulb B_2 gets fused, the equivalent resistance of parallel combination of B_1 and B_3 is

As $$\frac{1}{R'_P} = \frac{1}{R} + \frac{1}{R}$$

$$= \frac{2}{R} \qquad \text{(Bulbs are identical)}$$

$$\therefore \qquad R'_P = \frac{R}{2}$$

∴ Ammeter '*A*' reads now,

$$I' = \frac{V}{R'_P}$$

$$I' = \frac{4.5}{R/2}$$

$$= \frac{4.5 \times 2}{4.5} = 2\ \text{A}.$$

Since resistance of each arm is same and p.d. is also same, current divides them equally. So 1 A current will pass through each bulb B_1 and B_3. Therefore, ammeter A_1 and A_3 reads 1 A current while A_2 will read zero and *A* read 2 A current.

(*c*) In parallel, total power consumed

$$P_{eq} = P_1 + P_2 + P_3$$

So, when all the three bulbs glow together

$$P_{eq} = P + P + P$$

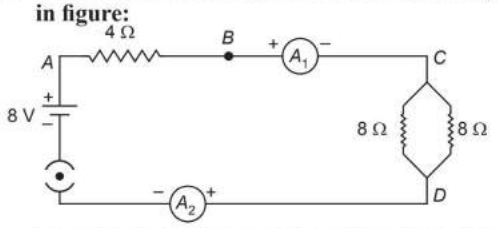
(As $P_1 = P_2 = P_3 = P$)

$$= 3P = 3 \times V \times I$$

$$= 3 \times 4.5 \times 1 = 13.5\ \text{W}.$$

(Current through each bulb = 1 A)

16. Find out the following in the electric circuit given in figure:



(*a*) Effective resistance of two 8 Ω resistors in the combination,

(*b*) Current flowing through 4 Ω resistor,

(*c*) Potential difference across 4 Ω resistance,

(*d*) Power dissipated in 4 Ω resistor, and

(*e*) Difference in ammeter readings, if any.

Ans. (*a*) Effective resistance, the two 8 Ω resistors are in parallel,

$$R_P = \frac{8 \times 8}{8 + 8} = 4\ \Omega$$

(*b*) $$R_{eq} = 4 + R_P = 8\ \Omega$$

So current through $4\ \Omega = I = \frac{V}{R} = \frac{8}{8} = 1\ \text{A}$

(*c*) Potential difference across resistance $4\ \Omega = V_1 = IR = 1 \times 4 = 4\ \text{V}$

(*d*) Power dissipated $= I^2R = 1^2 \times 4 = 4\ \text{W}$

(*e*) No difference, since the ammeters are connected in series and same current will pass through them, so reading of both ammeters would be same.