SOURAV KUMAR BISWAS
EDUCATION FOR ALL
SINCE 2018

Current Electricity

1. **What is Charge?**
   Ans. Electric **charge** is the physical property of matter that causes it to experience a force when placed in an electromagnetic field.
   - It is denoted by ‘q’ or ’Q’.
   - SI unit of charge is Coulomb (C)

2. **What is One Coulomb?**
   Ans. the quantity of electric charge which will deposit 0.00118 g of silver on the cathode, when passed through silver nitrate solution is called One Coulomb.

3. **What is Current?**
   Ans. The rate of flow of charge in an electrical circuit is called Electric Current.

   If a charge Q flows through a cross section normal to its direction of motion in time t, then current I through the conductor is given as,
   $$I = Q/t$$
   The SI Unit of Current is **Ampere (A).**

4. **What is One Ampere?**
   Ans. When one coulomb charge flows through an electric circuit in one second, then the current flowing through the circuit is said to be One Ampere.
   One Ampere = 1 Coulomb / 1 Second

5. **What is the relation between Current, Number of Electron flowing through an electric circuit and time?**
   Ans. We know $I=Q/t$
   If n electrons flow through a circuit such that charge on each electron is e^-
   Then,
   $Q=ne^-$
   Or $I=ne^-/t$

6. **What is Potential?**
   Ans. The amount of work done in moving a unit charge from infinity to a given point in an electric field is called Electric Potential.
   - It is a **scaler quantity.**
   - It is denoted by the Symbol **V.**
   - SI unit is **J/C or Volt**

   If W joule of work is done in bringing a charge Q coulomb from infinity to a point, then electric potential V at that point is given by
   $V=W/Q$
   Or $W=QV$

7. **What is One Volt?**
   Ans. When one coulomb charge is bought from infinity to a given point in an electric field, such that work done is one joule, then the electric potential at that point is one Volt.

Sourav Kumar Biswas 8697176834

8. **What is Potential Difference?**
Ans. The potential difference (p.d.) between two points is equal to the work don per unit charge in moving a positive test charge from one point to the other.
- It is a Scaler Quantity.
- Unit of Potential Difference is **Volt**
- Potential Difference is measured by a device called **Voltmeter**.

If W joule of work is done in moving a test charge Q coulomb from a point A to a point B. Then, the potential difference between the two points A and B is

$$V_A - V_B = W/Q$$

9. **What is Resistance?**
Ans. The obstruction offered to the flow of current by the conductor is called its Resistance.
- Unit of Resistance is **Ohms (Ω)**
- The resistance of a conductor depends upon the nature of the conductor.

10. **Define Ohm's Law?**
Ans. According to Ohm's law, the current flowing in a conductor is directly proportional to the potential difference applied across its ends provided that the physical conditions and the temperature of the conductor remain constant.

If a current I flows in a conductor when the potential difference across its end is V, then according to Ohm's Law

$I \propto V$

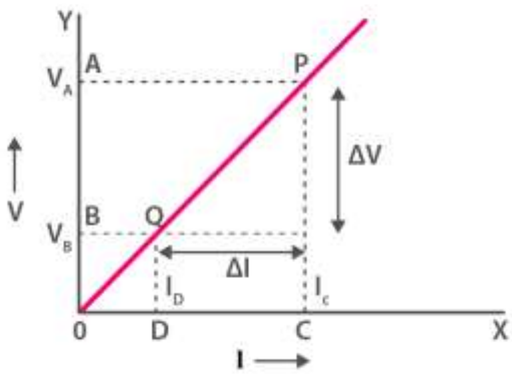
Or $V/I = \text{Constant}$

Or $V/I = R$ [Where R= Resistance of the conductor]
Or, $V = IR$

If $I = 1$ then $V = I$

Thus, the resistance of a conductor is numerically equal to the potential difference applied across its ends for the flow of unit current through it.

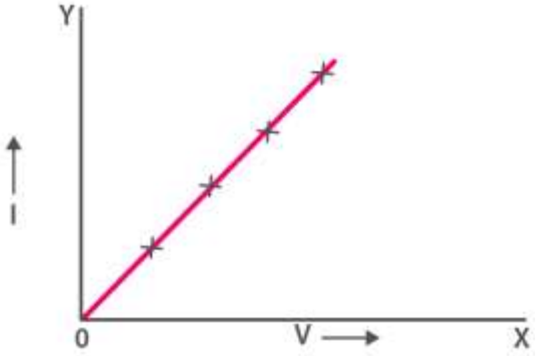
11. **Draw a V-I graph for a conductor obeying Ohm's law.**
What does the slope of V-I graph for a conductor represent?
Ans. V-I graph for a conductor obeying Ohm's law is given below



Slope of V-I graph for a conductor represents resistance.

Sourav Kumar Biswas
Education for all
Since 2018

12. Draw a I-V graph for a linear resistor. What does its slope represent?
Ans. I-V graph for a linear resistor



Slope of I-V graph: The slope of I-V graph is ΔI / ΔV
ΔI / ΔV is the reciprocal resistance of the conductor i.e.
Slope = ΔI / ΔV
= 1 / resistance of the conductor

13. What is Conductance?
Ans. The Reciprocal of the resistance is called Conductance.

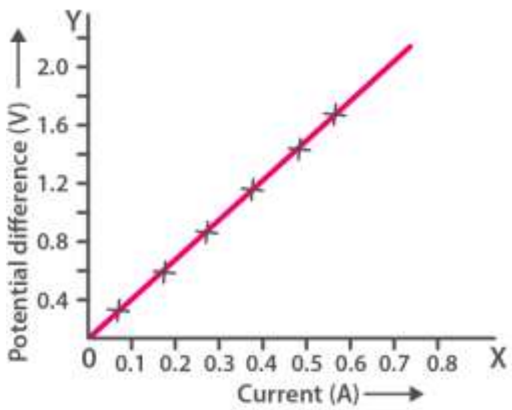
Conductance = 1/Resistance

- Unit of Conductance = ohm^{-1} or Siemen (S)

14. What are the limitations of Ohm's Law?
Ans. Ohm's Law is obeyed only when the temperature of the conductor remains constant.

15. What is Critical temperature, Superconductivity and Superconductors?
Ans. The particular temperature at which the resistance of a conductor becomes zero, i.e. it does not affect any resistance to the passage of electric current is called Critical temperature. This phenomenon is called Superconductivity and the conductor itself is called a Superconductor.

16. What is Ohmic Resistors? Give one example of an ohmic resistor. Draw a graph to show its current – voltage relationship. How is the resistance of the resistor determined from this graph?
Ans. The conductors which obey Ohm's Law are called Ohmic Resistors.
Ex: All metallic conductors.

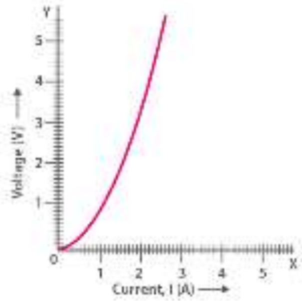


Resistance is determined in the form of slope from the above graph

Sourav Kumar Biswas 86971...34

17. What is Non-Ohmic Resistors? Give one example and draw a graph to show its current-voltage relationship.

Ans. The Conductors which do not obey Ohm's Law are called Non-Ohmic Resistors.
Ex: LED, Solar Cell



V vs I for non-ohmic conductors

18. Write the difference s between Ohmic Resistors and Non-ohmic Resistors?
Ans.

<u>Ohmic Resistors</u>	<u>Non-ohmic Resistors</u>
They obey oh1n 's law i.e., tl1e value of V/1 is a constant quantity for all values of V and I.	They do not obey ohm's law, i.e., the value of V/1 is not a constant quantity for all values of V and I
The graph between V against I is a straight line.	The graph between V and I is always a Curve.
The slope of the graph is a same for all the values of V and I.	The slope of graph is different for different values of V and I.
All metals and their alloys are ohmic resistors.	Armature coils of Electric Motor, electromagnet, ionic conductors, electronic valves, arc lights and electric bulb are non- ohmic resistor.

19. The resistance of a conductor depends on which factors?

Ans. The resistance of a conductor depends on the following factors:

a. Material of Conductor: Different materials have different concentration of free electrons and therefore the resistance of a conductor depends on its material. Metal such as silver, copper. aluminium, lead etc. have the concentration of free electron in the decreasing order, o their identical wires offer resistance in the increasing order.

b. Length of Conductor: In a long conductor, the number of collisions of free electrons with the positive ion will be more as compared to the shorter one. Therefore, a long conductor offers more resistance. In fact, the resistance of conductor is directly proportional to the length of the conductor.
The resistance R in the l length of the conductor is

$$R \infty l$$

c. Thickness of Conductor: In a thick conductor, electrons get a larger area of cross section to flow as compared to a thin conductor therefore a thick conductor offer less resistance. The resistance of a conductor is inversely proportional to its area of cross section.
The resistance R at cross section a is

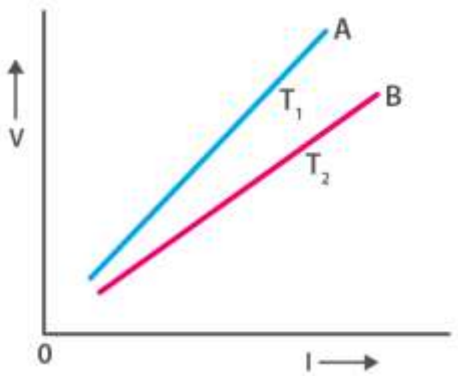
$$R \infty 1/a$$

d. Temperature of Conductor:
With the increase in temperature of a conductor, the random motion of electrons increases. As a result, the resistance of conductor increases with an increase in its temperature.

SOURAV KUMAR BISWAS
EDUCATION FOR ALL
SINCE 2018

20. Draw a V – I graph for a conductor at two different temperatures. What conclusion do you draw from your graph for the variation of resistance of conductor with temperature?

Ans.



In the given graph above $T_1 > T_2$. The straight-line A is steeper than the line B because the resistance of conductor is more at high temperature T_1 than at low temperature T_2. Hence, we can conclude that resistance of a conductor increases with the increase in temperature.

21. Two wires, one of copper and other of iron, are of the same length and same radius. Which will have more resistance? Give reason.

Ans. Iron has more resistivity as compared to copper which has less resistivity. So, greater the resistivity, the more the resistance is and the smaller the resistivity, the lesser the resistance. Hence, iron wire has more resistance than copper wire of the same length and same radius.

22. What is the relation between the resistance of a wire of l length and A cross sectional area?

Ans. The resistance of a conductor R is directly proportional to the length l, when the cross-sectional area is constant

Or, $R \infty l$ [When A is constant]

The resistance of a conductor is inversely proportional with the cross-sectional area A when the length is constant.

Or, $R x\infty 1/A$ [When l is constant]

So we can write

$R \infty l/A$

Or $R = \rho\, l/A$

Where ρ is a constant of proportionality, and is commonly known as Specific Resistance or Resistivity.

23. What is Specific Resistance?

Ans. Specific Resistance of a material is the resistance of wire of that material of unit length and unit cross section area.

- Unit of Specific Resistance is ohm × meter or Ωm

Sourav Kumar Bis... 834

24. State the order of specific resistance of (i) a metal, (ii) a semiconductor and (iii) an insulator.

Ans. (i) The specific resistance for metals is low, since it allows most of current to pass through it.
(ii) The specific resistance for semiconductor is more than metals
(iii) The specific resistance for insulators is very high, since the current won't pass through it

25. (a)Name two factors on which the specific resistance of a wire depends?
(b)Two wires A and B are made of copper. The wire A is long and thin while the wire B is Short and thick. Which will have more specific resistance?

Ans. (a) Two factors on which the specific resistance of a wire depends are
(i) Material of the substance and
(ii) Temperature of the substance
(b) Both the wires will have the same specific resistance because the specific resistance depends on the material of the wire and not its dimensions.

26. Name a substance of which the specific resistance remains almost unchanged by the increase in temperature.

Ans. The substance of which the specific resistance remains almost unchanged by the increase in temperature is manganin.

27. How does specific resistance of a semi-conductor change with the increase in temperature?

Ans. With the increase in temperature, specific resistance of a semi-conductor decreases.

28. What is Conductivity?

Ans. The reciprocal of specific resistance is known as conductivity. It is represented by the symbol σ(sigma).
Thus conductivity

$\sigma = 1/\rho$; $\sigma = l/Ra$

- SI unit is **$(\Omega m)^{-1}$ or Siemen metre^{-1}**

29. (a) Name the material used for making the connection wires. Give reason for your answer.
(b) Why should a connection wire be thick?

Ans. (a) Copper or aluminium are the materials used for making connection wires because they have small specific resistance and hence the wires of these materials possess negligible resistance
(b) The connection wires are made thick to consider their resistance as negligible to the flow of current through the circuit.

30. Name the material used for making a fuse wire. Give a reason.

Ans. Alloy of lead and tin is used for making a fuse wire because it has high resistivity and low melting point.

31. Explain the meaning of the terms e.m.f., terminal voltage and internal resistance of cell.

Ans. The e.m.f of a cell is defined as the energy spent per unit charge in taking a positive test charge around the complete circuit of the cell.
If W work is done in taking a test charge q around the complete circuit of the cell, then emf of the cell is

$$\varepsilon = W/q$$

SOURAV KUMAR BISWAS
EDUCATION FOR ALL
SINCE 2018

Terminal voltage: When the cell is in closed circuit, the potential difference between the electrodes of the cell is known as terminal voltage.

Internal resistance: The resistance offered by the electrolyte inside the cell, to the flow of current, is known as the internal resistance of the cell.

32. State two differences between the e.m.f. and terminal voltage of a cell.

Ans.

e.m.f of cell	Terminal voltage of cell
1. It is measured by the amount of work done per unit change in moving a positive test charge in the complete circuit inside and outside the cell.	1. It is measured by the amount of work done per unit charge in moving a positive test charge in the circuit outside the cell.
2. It is the characteristic of the cell, i.e., it does not depend on the amount of current drawn from the cell	2. It depends on the amount of current drawn from the cell. More the current drawn from the cell, less is the terminal voltage
3. It is equal to the terminal voltage when the cell is not in use, while greater than the terminal voltage when cell is in use	3. It is equal to the e.m.f. of cell when cell is not in use, while less than the e.m.f. when cell is in use.

33. On which factors emf of a cell depends?
Ans. The emf of a cell depends on
a. The material of the electrodes
b. The electrolyte used in the cell.

34. On which factors the emf of cell is not depends?
Ans. The factors of emf is not depends on
a. The shape of electrodes
b. The distance between the electrodes and
c. The amount of electrolyte in the cell.

35. What is terminal voltage of a cell?
Ans. The terminal voltage of a cell is defined as the work done per unit charge in carrying a positive test charge around the circuit connected across the terminals of the cell.
If W is the work done in carrying a test charge q around the circuit across the terminals of a cell, then the terminal voltage of the cell is

$$V = w/q$$

36. What is Voltage drop in the cell?
Ans. The work done per unit charge in carrying the positive test charge through the electrolyte is called the voltage drop in the cell.
If w is the work done in carrying a test charge q through the electrolyte inside the cell. Then the quantity w/q is called the voltage drop in the cell which is denoted as v

i.e. Voltage drop in the cell $v = w/q$

37. **What is the relation between e.m.f and terminal voltage of a cell?**

Ans. If W is the work done in moving a test charge q outside as well as inside the cell, W' is the work done in moving the test charge q outside the cell and w is the work done in moving the teat charge q inside the electrolyte of the cell

Then by the law of conservation of energy,

$$W=W' + w$$

Dividing the above equation by q on both sides, we get.

$$W/q= W'/q + w/q$$

Or, $\mathcal{E} = V+v$ [Where $\mathcal{E}$ = e.m.f of the cell , V and v= Voltage Drop]

Or, $\mathbf{V= \mathcal{E}+v}$

Thus, when current is drawn from a cell, its terminal voltage V is less than its e.m.f $\mathcal{E}$ by n amount equal to the voltage drop v inside the cell.

38. **What is Internal Resistance of a cell?**

Ans. The resistance offered by the electrolyte inside the cell to the flow of current, is called Internal Resistance of the cell.

When current I is drawn from the cell of which internal resistance is r, then the voltage drop is

$$\mathbf{v= Ir}$$

39. **What is the relation between e.m.f, terminal voltage and internal resistance of the cell?**

Ans. Let a cell of e.m.f $\mathcal{E}$ and internal resistance r be used to send current in an external resistance R connected across the cell.

Now

Total resistance of circuit= R+r

Current drawn from the cell

I= emf of the cell / Total resistance = $\mathcal{E}$/R+r

e.m.f of the cell $\mathcal{E}$=I(R+r)

$\mathcal{E}$=IR+Rr

Terminal voltage of the cell

V=IR ----------------------------- -(i)

And Voltage drop due to internal resistance is

V= Ir ----------------------------- (ii)

So, e.m.f of the cell $\mathcal{E}$= V+v

Or v= $\mathcal{E}$-V

Now from the eq (i)

r= V/I

or r= $\mathcal{E}$-V / I

or r= $\mathcal{E}$-V / V/R [From the eq i=V=IR]

or $\mathbf{r=(\frac{\mathcal{E}}{V} - 1)R}$

SOURAV KUMAR BISWAS
EDUCATION FOR ALL
SINCE 2018

40. On which factors the Internal Resistance of a cell depends?

Ans. The internal resistance of a cell depends on the following four factors

a. The surface area of the electrodes: Larger the surface area of electrodes, less is the internal resistance.
b. The distance between the electrodes: More the distance between the electrodes, greater is the internal resistance.
c. The nature of the concentration of the electrolyte: Less ionic the electrolyte or higher the concentration of the electrolyte, greater is the internal resistance.
d. The temperature of the electrolyte: Higher the temperature of the electrolyte, less is the internal resistance.

41. Express the equivalent resistance of Series Resistance?

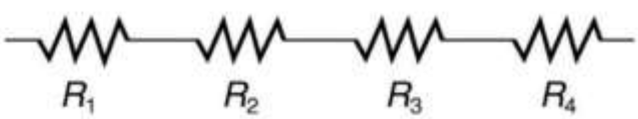
Ans. According to Ohm's law, the voltage drops, V, across a resistor when a current flows through it is calculated by using the equation V=IR, where I is current in amps (A) and R is the resistance in ohms (Ω).

So the voltage drop across R_1 is $V_1=IR_1$, across R_2 is $V_2=IR_2$, and across R_3 is $V_3=IR_3$. The sum of the voltages would equal: $V=V_1+V_2+V_3$, based on the conservation of energy and charge. If we substitute the values for individual voltages, we get:

V=IR1+IR2+IR3

Or V=I(R1+R2+R3)

Or V=I(R1+R2+R3)



This implies that the total resistance in a series is equal to the sum of the individual resistances. Therefore, for every circuit with *N* number of resistors connected in series:

R_N (series)=R1+R2+R3+…+R_n.

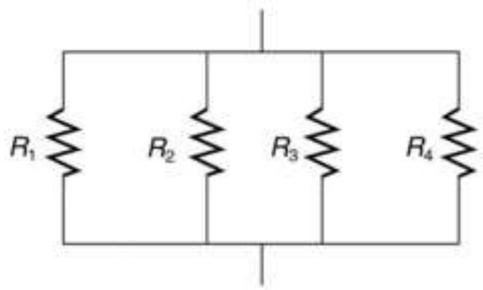
42. Express the equivalent resistance of Parallel Resistance?

Ans. Each resistor in the circuit has the full voltage. According to Ohm's law, the currents flowing through the individual resistors are

$$I_1 = V/R_1, I_2 = V/R_2, I_3 = V/R_3$$

Conservation of charge implies that the total current is the sum of these currents:

$I=I_1+I_2+I_3$



Substituting the expressions for individual currents gives:

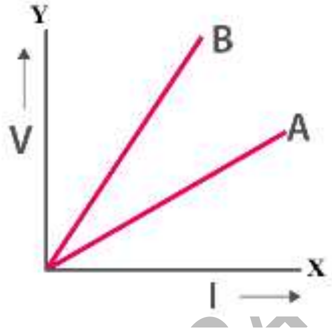
$$I= V/R_1 + V/R_2 + V/R_3$$

This implies that the total resistance in a parallel circuit is equal to the sum of the inverse of each individual resistance. Therefore, for every circuit with n number or resistors connected in parallel.

$$R_{(parallel)}=R_1R_2R_3R_4/ R_1 + R_2 +R_3 +R_4$$

43. The V-I graph for a series combination and for a parallel combination of two resistors is shown in fig. Which of the two, A or B, represents the parallel combination? Give a reason for your answer.

Ans. Change in V is less for the straight-line A than for the straight-line B (which means the straight-line A is less steep than B). Hence, the straight-line A represents small resistance and the straight-line B represents more resistance. The resistance decreases in parallel combination while the resistance increases in series combination. Thus, the straight-line A represents the parallel combination.



44. What is the expression of Electrical Energy?

Ans. Let a current I be flowing through a conductor of resistance R for time t, when a source of potential difference V is connected across its ends.

Due to flow of current I for time t, the amount of charge passed is

$Q= I \times t$

By the definition of potential difference, work needed to move a charge Q through a potential difference V is

$W = QV$

$W=VIt$ Because $[Q= I \times t]$

Now, according to the Ohm's Law

$V=IR$

So $W=I^2Rt$

Or $W= (V/R)^2Rt = V^2t/R$

Thus, electrical energy supplied by the source is

$$\mathbf{W=QV = Vit=I^2Rt= V^2t/R}$$

- SI unit of Electrical Energy is **Joule.**

45. What is Electrical Power?

Ans. In an electric circuit, the electric power is defined as the rate at which the electrical energy is supplied by the source.

If a source of potential difference V sends a current I for time t in a resistance R,

Then the charge passed is $Q=It$

And the energy supplied by the source is $W= QV$

Then, Power P =energy supplied W / time t

Or, $P = QV/t$

Now $Q =It$

So, $P=VIt/t$

$P= VI$

Now by Ohm's Law

$I= V/R$

So $P=V^2/R$

Since, $V=IR$

So, $P=(IR)^2/R$

$P= I^2R$

This Electrical Power

$$\mathbf{P = W/t =VI = V^2/R=I^2R}$$

- SI Unit of Electrical Power = Volt Ampere or Watt (W) or Js^{-1}

46. What is One Watt?

Ans. One watt is the electric power consumed when a current of 1 ampere flows through a circuit having potential difference of 1 Volt.

47. What is Watt-hour?

Ans. One Watt hour is the electrical energy consumed by an electrical appliance of power 1 watt when it is used for 1 hour.

1 Watt-hour = 1 watt × 1 hour
= 1 watt × (60×60) sec = 3600J

48. What is Kilowatt-hour?

Ans. One Kilowatt hour is the electrical energy consumed by an electrical appliance of power 1 kilowatt when it is used for 1 hour

1kilowatt-hour or 1 kHh = 1 kilowatt × 1 hour
=1000 watt ×(60×60) sec
=1000 Js^{-1}× 3600 sec
= 3.6 ×10^6 J

49. Write an expression for the electrical energy spent in flow of current through an electrical appliance in terms of current, resistance and time.

Ans. The expression for the electrical energy spent in flow of current through an electrical appliance in terms of current, resistance and time is
Electrical energy, W = I^2Rt joule

50. Write an expression for the electrical power spent in flow of current through a conductor in terms of (a) resistance and potential difference, (b) current and resistance.

Ans. (a) Expression for electrical power spent in flow of current through a conductor in terms of resistance and potential difference is
Electrical Power, P = V^2 / R
(b) Expression for electrical power spent in flow of current through a conductor in terms of current and resistance is
Electrical Power, P = I^2R

51. 'The rating of an Electric bulb is 100 W 220 V'- What is its mean?

Ans. An electric bulb is rated as 100 W 220V, it means that if the bulb is lighted on a 220V supply, the electric power consumed by it is 100W.

52. What can we calculate from the power rating?

Ans. From the rating of an appliance we can calculate the following two quantities:
a. The resistance of its filament or element when it is used and
b. The safe limit of current which can flow through the appliance while in use.

53. What is Safe Current?

Ans. Resistance of an electrical appliance is
R = V^2/P
R= (Voltage ratting on the appliance)^2/ power rating on the appliance
And the current passes through the element is
I= P/V
If the current exceeds this value, the power supplied at a voltage V will exceed the rated power of the appliance may get damaged.
This value of current is called Safe Current.
Safe Current = Power rating on the appliance / Voltage rating on the appliances

54. How can we calculate electrical energy of household appliances?

Ans. The electrical energy consumed by household appliances in a certain time can be calculated in kWh by the following relation:

Energy (kWh) = Power (kW)× time (Hour)

= Power (in Watt) × Time (Hour)/1000

= V(Volt) × I (ampere) × t (hour)/1000

55. Name the factors on which the heat produced in a wire depends when current is passed in it, and state how does it depend on the factors stated by you.

Ans. The amount of heat produced in a wire on passing current through it, depends on the following three factors.

(i) The amount of current passing through the wire: Dependence of heat produced on the current in wire: The amount of heat H produced in the wire is directly proportional to the square of current I passing through the wire, i.e., $H \propto I^2$

(ii) The resistance of wire: Dependence of heat produced on the resistance of wire: The amount of heat H produced in the wire is directly proportional to the resistance R of the wire, i.e., $H \propto R$

and

(iii) The time for which current is passed in the wire: Dependence of heat produced on the time: The amount of heat H produced in a wire is directly proportional to the time t for which current is passed in the wire i.e., $H \propto t$

Sourav Kumar Biswas

SOURAV KUMAR BISWAS
EDUCATION FOR ALL
SINCE 2018

Important Formulas

If

a. E= No.of Free electrons
b. Q= Amount of Charge
c. I = Flow of Current
d. l= Length of the wire
e. a= Cross sectional area of wire
f. R= Resistance of Wire
g. t= Time
h. V= Potential Difference
i. W= Work Done in Joule
j. ρ = Specific Resistance
k. σ=Conductivity of Wire in siemen metre^{-1}
l. $\mathcal{E}$= e.m.f

1) I= Q/t Amp. Or I= ne/t
2) V=W/Q J/C
3) R= V/I Ohm.
4) R= $\rho\ l/a$
5) σ= l/Ra
6) $\mathcal{E}$=W/q
7) Terminal Voltage V= $\mathcal{E}$ +v
8) Relation between emf, Terminal Voltage and Internal Resistance is: $r=(\frac{\mathcal{E}}{V} - 1)R$
9) Equivalent resistance of series Resistors: $R_s=R_1+R_2+R_3+.....+R_n$
10) Equivalent resistance of Parallel Series is $Rn(parallel)=1/(1/R_1)+(1/R_2)+(1/R_3)+...+(1/Rn)$.
11) 1 Watt hour = 3600J
12) Electrical Power P = W/t =VI = $V^2/R=I^2R$
13) Electrical Energy of Household appliances is, Energy (kWh)= V(Volt) × I (ampere) × t (hour)/1000
14) Cost of Electricity = electric energy in kWh × cost per kWh

1. **In a conductor, 6.25×10^{16} electrons flow from its end A to B in 2 s. Find the current flowing through the conductor. ($e = 1.6 \times 10^{-19}$ C)**
Ans. Given
Number of electrons flowing through the conductor,
$n = 6.25 \times 10^{16}$ electrons.
Time taken to flow from A to B = 2 s and $e = 1.6 \times 10^{-19}$ C
Let I be the current flowing through the conductor
Now, $I = ne / t$
Therefore $I = [(6.25 \times 10^{16}) (1.6 \times 10^{-19})] / 2$
$I = 5 \times 10^{-3}$ A or
I = 5 m A
Hence, 5 mA current flows from B to A

2. **A current of 1.6 mA flows through a conductor. If charge of an electron is -1.6×10^{-19} coulomb, find the number of electrons that will pass each second through the cross section of that conductor.**
Ans. Given
Current, I = 1.6 m A or
$I = 1.6 \times 10^{-3}$ A
Charge, $Q = -1.6 \times 10^{-19}$ coulomb
t = 1 s
$I = Q / t$
$Q = I \times t$
$Q = 1.6 \times 10^{-3} \times 1$
Number of electrons $= 1.6 \times 10^{-3} / 1.6 \times 10^{-19}$
∴ Number of electrons $= 10^{16}$

3. **Find the potential difference required to flow a current of 200 mA in a wire of resistance 20 ohm.**
Ans Given
Current I = 200 mA
I = 0.2 A
Resistance R = 20 ohm
Potential difference V =?
Using Ohm's law
V = IR
$V = 0.2 \times 20$
V = 4 V

4. **Two wires of the same material and same length have radii 1 mm and 2 mm respectively. Compare (i) their resistances (ii) their specific resistance.**
Ans. (i) For wire of radius r_1
$R_1 = \rho (l / A_1)$
$R_1 = \rho (l / \pi r_1^2)$
(ii) For wire of radius r_2
$R_2 = \rho (l / A_2)$
$R_2 = \rho (l / \pi r_2^2)$
∴ $R_1: R_2$ will be
$\rho (l / \pi r_1^2) : \rho (l / \pi r_2^2)$
$= r_2^2: r_1^2$
(ii) The resistivities of the two wires will be same because the material of the two wires is same. That is
$\rho_1: \rho_2 = 1: 1$

5. An electric bulb draws 1.2 A current at 6.0 V. Find the resistance of filament of bulb while glowing.

Ans. Given
Current I = 1.2 A
Potential difference or Voltage V = 6.0 V
Resistance R =?
From Ohm's law
V = IR
R = V / I
R = 6 / 1.2
R = 5 Ohm

6. A car bulb connected to a 12-volt battery draws 2 A current when glowing. What is the resistance of the filament of the bulb? Will the resistance be more, same or less when the bulb is not glowing?

Ans. Given
Potential difference or Voltage V = 12 V
Current I = 2 A
Resistance =?
According to Ohm's law
V = IR
R = V / I
R = 12 / 2
R = 6 Ohm
Hence, when bulb is not glowing, resistance will be less.

7. Calculate the current flowing through a wire of resistance 5 Ohm connected to a battery of potential difference 3 V.

Ans. Given
Potential difference or Voltage V = 3 V
Resistance R = 5 Ohm
Current =?
From Ohm's law
V = IR
I = V / R
I = 3 / 5
I = 0.6 A

8. What length of copper wire of specific resistance 1.7×10^{-8} ohm m and radius 1 mm is required so that its resistance is 1 ohm?

Ans. Given
Resistance R = 1 ohm
Specific resistance = 1.7×10^{-8} ohm m
Radius r = 1 mm that is 10^{-3} m
Length l =?
$R = \rho\, 1 / A$
$l = RA / \rho$
$l = R\pi r^2 / \rho$
$l = (1 \times \pi \times 10^{-6}) / (1.7 \times 10^{-8})$
$l = (1 \times 3.14 \times 10^{-6}) / (1.7 \times 10^{-8})$
$l = 1.847 \times 10^{2}$ m
$l = 184.7$ m

9. **A wire of resistance 9 Ohm having length 30 cm is tripled on itself. What is its new resistance?**

Ans. Given

Resistance R = 9 Ohm

Length l = 30 cm

New length l' = 3 × l

New resistance R'=?

Area of cross section will also change in same order with change in length

R' = ρ (l / 3 / 3A)

R' = 1 / 9 (ρ l / A)

R' = 1 / 9 R

R' = 1 Ohm

10. **In an experiment of verification of Ohm's law, following observations are obtained.**

Potential difference V (in volt)	**0.5**	**1.0**	**1.5**	**2.0**	**2.5**
Current I (in amp)	**0.2**	**0.4**	**0.6**	**0.8**	**1.0**

Draw a characteristic V-I graph and use this graph to find:

(a) potential difference V when the current I is 0.5 A.

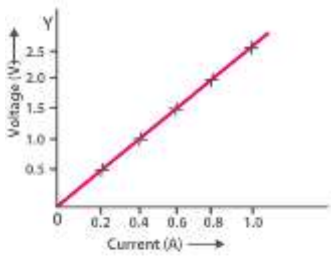
(b) current I when the potential difference V is 0.75 V.

(c) resistance in circuit

Ans. (a) Potential difference is 1.25 V when the current is 0.5A

(b) Current is 0.3 A when the potential difference is0.75V

(c) The graph is linear and thus resistance can be found from any value of the given table.



If V = 2.5 Volt then

Current I = 1.0 amp

Using Ohm's law

R = V / I

R = 2.5 / 1.0

R = 2.5 Ohm

11. **The filament of a bulb takes a current 100 mA when potential difference across it is 0.2 V. When the potential difference across it becomes 1.0 V, the current becomes 400 mA. Calculate the resistance of filament in each case and account for the difference.**

Solution:

From Ohm's law

V = IR

R = V / I

$R_1 = V_1 / I_1$

$R_1 = 0.2 / 0.1$

$R_1 = 2$ ohm

Similarly

$R_2 = V_2 / I_2$

$R_2 = 1 / 0.4$

$R_2 = 2.5$ ohm

∴ With increase in temperature resistance of the wire increases. Thus, resistance of filament increases with the increase in temperature.

12. A given wire of resistance 1 Ohm is stretched to double its length. What will be its new resistance?

Ans. Let 'I' be the length and 'a' be the area of cross section of the resistor with resistance, R = 1 Ohm

A given wire is stretched to double its length,

Therefore, length $l' = 2l$ and area of cross section $a' = a / 2$

Now Resistance $(R') = \rho\ l'/ a'$

$R' = \rho\ 2l / a / 2$

$R' = 4\ \rho\ (1 / a)$

$R' = 4R$

$R' = 4 \times 1$

$R' = 4$ Ohm

13. A wire of resistance 3 Ohm and length 10 cm is stretched to length 30 cm. Assuming that it has a uniform cross-section, what will be its new resistance?

Ans. Given

Resistance R = 3 Ohm

Length l = 10 cm

The new length $l' = 30\ cm = 3 \times l$

$R = \rho\ (l / A)$

New resistance

Stretching length will increase and area of cross section will decrease in same order

$R' = \rho\ (3l / A / 3)$

Hence,

$R' = 9\ \rho\ (l / A)$

$R' = 9R$

$R' = 9 \times 3$

$R' = 27$ Ohm

14. A battery of emf 15 V and internal resistance 3 ohm is connected to two resistors of resistances 3 ohm and 6 ohm in series. Find:
(a) the current through the battery
(b) the p.d. between the terminals of the battery.

Ans. (a) $\varepsilon = 15$ V

$R = 6 + 3$

$R = 9$ ohm

$r = 3$ ohm

$I = \varepsilon / (R + r)$

$I = 15 / (9 + 3)$

$I = 15 / 12$

$I = 1.25$ A

(b) Current $I = 1.25$ A [calculated in part (a)]

External resistance $R = 6 + 3$

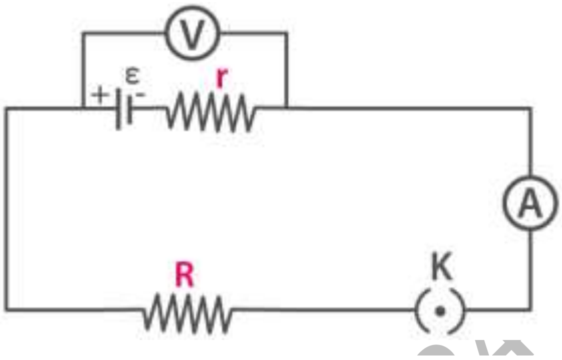
$R = 9$ ohm

$V = IR$

$V = 1.25 \times 9$

$V = 11.25$ V

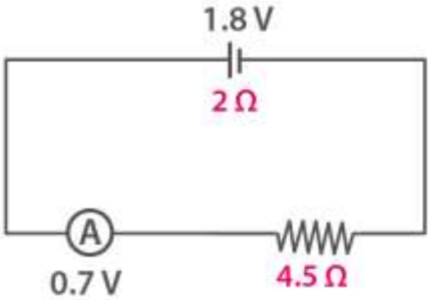
15. **The diagram in figure shows a cell of e.m.f. ε = 2 volt and internal resistance r = 1 ohm connected to an external resistance R = 4 ohm. The ammeter A measures the current in the circuit and the voltmeter V measures the terminal voltage across the cell. What will be the readings of the ammeter and voltmeter when (i) the key K is open, and (ii) the key K is closed**



Ans. (i) Because of no current,
ammeter reading = 0
Voltage V = ε – Ir
V = 2 – 0 × 1
V = 2 volt
(ii) Ammeter reading
I = ε / (R + r)
I = 2 / (4 + 1)
I = 2 / 5
I = 0.4 amp
Voltage reading
Voltage V = ε – Ir
V = 2 – 0.4 × 1
V = 2 – 0.4
V = 1.6 V

16. **Two resistors having resistance 4 ohm and 6 ohm are connected in parallel. Find their equivalent resistance.**
Ans. Let the equivalent resistance of the 4 ohm and 6 ohm resistors connected in parallel be R'
Then, 1 / R' = 1 / 4 + 1 / 6
= (3 + 2) / 12
= 5 / 12 ohm or
R' = 12 / 5
R' = 2.4 ohm

17. **A cell of emf 1.8 V and internal resistance 2 ohm is connected in series with an ammeter of resistance 0.7 ohm and resistance of 4.5 ohm as shown in figure.**
(a) What would be the reading of the ammeter?
(b) What is the potential difference across the terminals of the cell?



Ans. (a) ε = 1.8 V
Total resistance = 2 + 4.5 + 0.7
= 7.2 W
I = ε / R (total resistance)
I = 1.8 / 7.2
I = 0.25 A
(b) Current I = 0.25 A [calculated in (a) part]
Now, excluding internal resistance total resistance = 4.5 + 0.7
= 5.2 ohm

V = IR
V = 0.25 × 5.2
V = 1.3 V

18. A cell of e.m.f. ε and internal resistance r sends current 1.0 A when it is connected to an external resistance 1.9 ohm. But its sends current 0.5 A when it is connected to an external resistance of 3.9 ohm. Calculate the values of e and r.

Ans. In first case
$I = 1$ A, $R = 1.9$ ohm
$\varepsilon = I (R + r)$
$= 1 (1.9 + r)$
$= 1.9 + r$ [1]
In second case
$I = 0.5$ A, $R = 3.9$ ohm
$\varepsilon = I (R + r)$
$= 0.5 (3.9 + r)$
$= 1.95 + 0.5r$ [2]
From equation [1] and [2]
$1.9 + r = 1.95 + 0.5r$
$r = 0.05 / 0.5$
$r = 0.1$ ohm
Now, substituting the value of r
$\varepsilon = 1.9 + r$
$\varepsilon = 1.9 + 0.1$
$\varepsilon = 2$ V

19. Four resistors each of resistance 2 ohm are connected in parallel. What is the effective resistance?

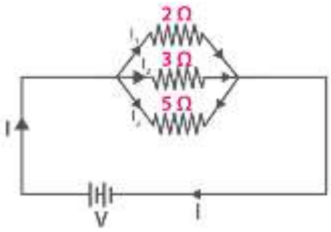
Ans. $R_1 = 2$ ohm
$R_2 = 2$ ohm
$R_3 = 2$ ohm
$R_4 = 2$ ohm
$1 / R = 1 / R_1 + 1 / R_2 + 1 / R_3 + 1 / R_4$
$1 / R = 1 / 2 + 1 / 2 + 1 / 2 + 1 / 2$
$1 / R = 2$
$R = 0.5$ ohm

20. A combination consists of three resistors in series. Four similar sets are connected in parallel. If the resistance of each resistor is 2 ohm, find the resistance of the combination.

Ans. Resistance of each set:
$r_1 = 2 + 2 + 2 = 6$ ohm
$r_2 = 2 + 2 + 2 = 6$ ohm
$r_3 = 2 + 2 + 2 = 6$ ohm
$r_4 = 2 + 2 + 2 = 6$ ohm
Now, the above resistances are arranged in parallel
$1 / r = 1 / r_1 + 1 / r_2 + 1 / r_3 + 1 / r_4$
$1 / r = 1 / 6 + 1 / 6 + 1 / 6 + 1 / 6$
$1 / r = 4 / 6$
$r = 6 / 4$
$r = 1.5$ ohm

21. You have three resistors of values 2 Ω, 3 Ω and 5 Ω . How will you join them so that the total resistance is less than 1 Ω? Draw diagram and find the total resistance.

Ans. To get a total resistance less than 1 Ω, the three resistors should be connected in parallel



Let the total resistance be R'

Then, $1 / R' = 1 / 2 + 1 / 3 + 1 / 5$

$1 / R' = (15 + 10 + 6) / 30$

$1 / R' = 31 / 30$ Ω or

$R' = 30 / 31$

$R' = 0.97$ Ω

22. A uniform wire with a resistance of 27 ohm is divided into three equal pieces and then they are joined in parallel. Find the equivalent resistance of the parallel combination.

Ans. Since the wire is divided into three pieces, the new resistance = 27 / 3 = 9

Now, three resistance are joined in parallel

$1 / r = 1 / r_1 + 1 / r_2 + 1 / r_3$

$1 / r = 1 / 9 + 1 / 9 + 1 / 9$

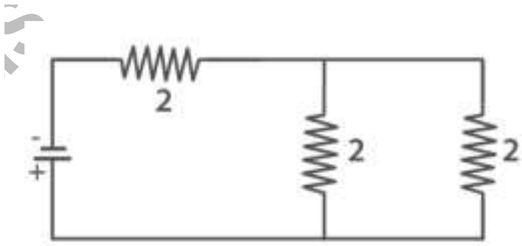
$1 / r = 3 / 9$

$1 / r = 1 / 3$

r = 3 ohm

23. Three resistors each of 2 W are connected together so that their total resistance is 3 W. Draw a diagram to show this arrangement and check it by calculation.

Ans. A parallel combination of two resistors, in series with one resistor.



$R_1 = 2$ ohm

$R_2 = 2$ ohm

$R_3 = 2$ ohm

$1 / R' = 1 / R_1 + 1 / R_2$

$1 / R' = 1 / 2 + 1 / 2$

$1 / R' = 1$

R' = 1 ohm

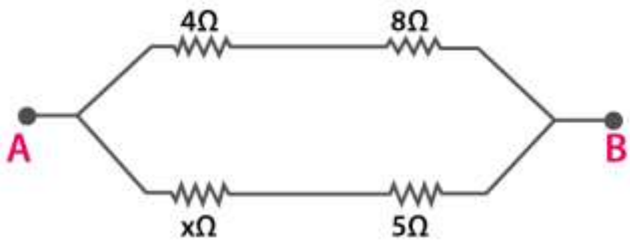
$R = R' + R_3$

$R = 1 + 2$

R = 3 ohm

24. In the circuit shown below in figure, calculate the value of x if the equivalent resistance between the points A and B is 4 ohm

Ans. $r_1 = 4$ ohm



$r_2 = 8$ ohm

$r_3 = x$ ohm

$r_4 = 5$ ohm

r = 4 ohm

$r' = r_1 + r_2$

$r' = 4 + 8$

r' = 12 ohm

$r'' = r_3 + r_4$

r'' = (x + 5) ohm

$1 / r = 1 / r' + 1 / r''$

$1 / 4 = 1 / 12 + 1 / (5 + x)$

$1 / 4 – 1 / 12 = 1 / (5 + x)$

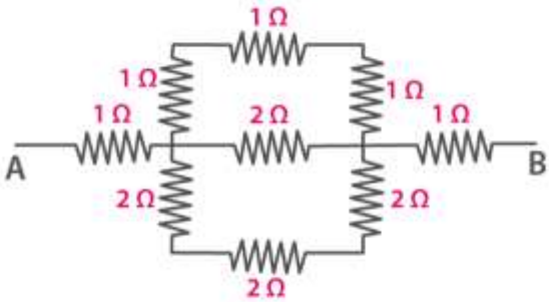
$(3 – 1) / 12 = 1 / (5 + x)$

$2 / 12 = 1 / (5 + x)$

$1 / 6 = 1 / (5 + x)$

x = 1 ohm

25. Calculate the effective resistance between the points A and B in the circuit shown in figure



Ans.

In the figure,

Resistance between XAY = (1 + 1 + 1)

= 3 ohm

Resistance between XY = 2 ohm

Resistance between XBY = 6 ohm

Let the net resistance between the points X and Y be R'

Then, 1 / R' = 1 / 2 + 1 / 3 + 1 / 6

1 / R' = (3 + 2 + 1) / 6

1 / R' = 6 / 6

1 / R' = 1 ohm or

R' = 1 ohm

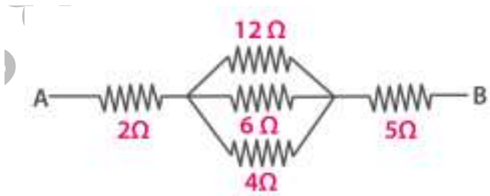
Therefore, we can say that three 1-ohm resistors are connected in series between points A and B

Let the net resistance between points A and B be R_{AB}

Then, R_{AB} = (1 + 1 + 1) ohm

R_{AB} = 3 ohm

26. Calculate the effective resistance between the points A and B in the network shown below in figure.



Ans. For parallel resistance

1 / R = 1 / 12 + 1 / 6 + 1 / 4

1 / R = (1 + 2 + 3) / 12

1 / R = 6 / 12

R = 12 / 6

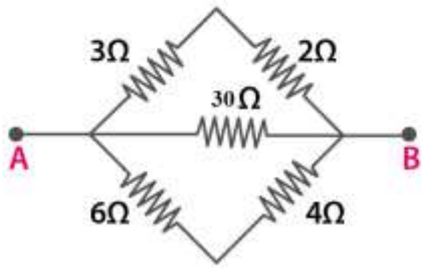
R = 2 ohm

Now, all the resistances are in series

R = 2 + 2 + 5

R = 9 ohm

27. Calculate the equivalent resistance between the points A and B in figure



Ans. Given

R_1 = 3 + 2 = 5 ohm

R_2 = 30 W

R_3 = 6 + 4 = 10 ohm

The resistors R_1, R_2 and R_3 are connected in parallel

1 / R = 1 / R_1 + 1 / R_2 + 1 / R_3

1 / R = 1 / 5 + 1 / 30 + 1 / 10

1 / R = (6 + 1 + 3) / 30

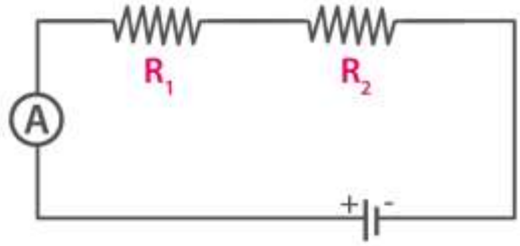
1 / R = 10 / 30

1 / R = 1 / 3

R = 3 ohm

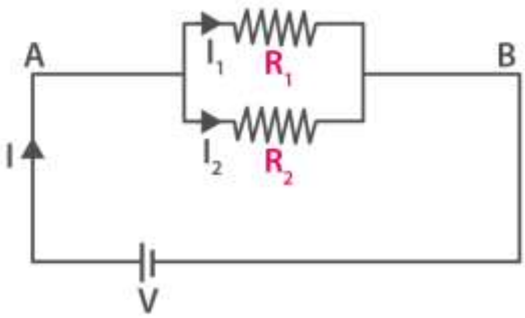
28. Two resistors of 2 ohm and 3 ohm are connected (a) in series, (b) in parallel, with a battery of 6.0 V and negligible internal resistance. For each case draw a circuit diagram and calculate the current through the battery.

Ans. (a)



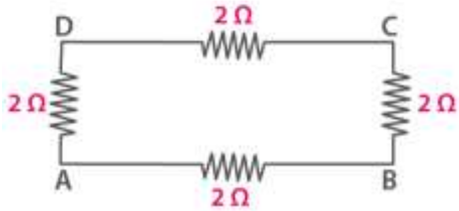
$R_1 = 2$ ohm
$R_2 = 3$ ohm
$R = R_1 + R_2$
$R = 2 + 3$
$R = 5$ ohm
$V = 6$ V
Now, $I = V / R$
$I = 6 / 5$
$I = 1.2$ ohm

(b) Here, R_1 and R_2 are connected in parallel



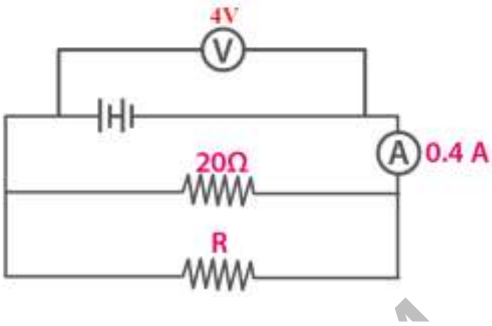
$1 / R = 1 / R_1 + 1 / R_2$
$1 / R = 1 / 2 + 1 / 3$
$1 / R = (3 + 2) / 6$
$1 / R = 5 / 6$
$R = 6 / 5$
$R = 1.2$ ohm
$V = 6$ V
We know that,
$I = V / R$
$I = 6 / 1.2$
$I = 5$ A
Therefore, in series: 1.2 A and in parallel: 5 A

29. In the network shown in adjacent figure, calculate the equivalent resistance between the points (a) A and B (b) A and C



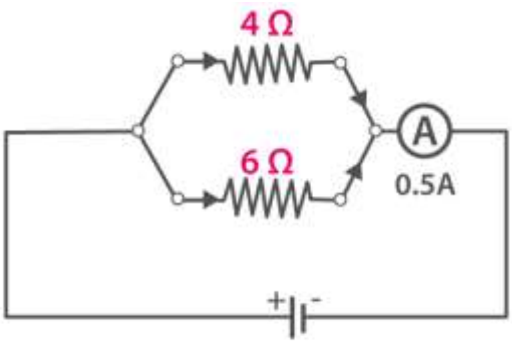
Ans. (a) $R_1 = 2 + 2 + 2$
$R_1 = 6$ ohm
$R_2 = 2$ ohm
R_1 and R_2 are connected in parallel
$1 / R = 1 / R_1 + 1 / R_2$
$1 / R = 1 / 6 + 1 / 2$
$1 / R = (1 + 3) / 6$
$1 / R = 4 / 6$
$R = 6 / 4$
$R = 1.5$ ohm
(b) $R_1 = 2 + 2$
$R_1 = 4$ ohm
$R_2 = 2 + 2$
$R_2 = 4$ ohm
The resistors R_1 and R_2 are connected in parallel
$1 / R = 1 / R_1 + 1 / R_2$
$1 / R = 1 / 4 + 1 / 4$
$1 / R = 2 / 4$
$1 / R = 1 / 2$
$R = 2$ ohm

30. In figure, calculate: (a) the total resistance of the circuit. (b) the value of R, and (c) the current flowing in R



Ans. (a) To calculate the total resistance of the circuit
V = 4 V
I = 0.4 A
Total resistance R' =?
R' = V / I
R' = 0.4 / 4
R' = 10 ohm
(b) To calculate the value of R
R_1 = 20 ohm
R' = 10 ohm
1 / R'= 1 / R + 1 / R_1
1 / 10 = 1 / R + 1 / 20
1 / R = 1 / 10 – 1 / 20
1 / R = (2 – 1) / 20
1 / R = 1 / 20
R = 20 ohm
(c) To calculate the current flowing in R
R = 20 ohm
V = 4 V
I = V / R
I = 4 / 20
I = 0.2 A

31. Two resistors of resistance 4 Ω and 6 Ω are connected in parallel to a cell to draw 0.5 A current from the cell.
(a) Draw a labelled diagram of the arrangement
(b) Calculate current in each resistor.

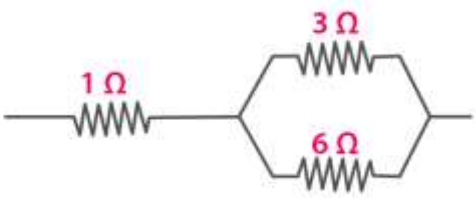


Ans.(a) Circuit diagram
(b) Equivalent resistance of the circuit
1 / R = 1 / 4 + 1 / 6
1 / R = (3 + 2) / 12
1 / R = 5 / 12
R = 12 / 5
R = 2.4 ohm
Thus, the e.m.f. of the cell is
V = IR
V = 0.5 × 2.4
V = 1.2 V
∴ Current through each resistor is
$I_4 = V / R_4$
I_4 = 1.2 / 4
I_4 = 0.3 A
$I_6 = V / R_6$
I_6 = 1.2 / 6
I_6 = 0.2 A
Hence, 0.3 A in 4 ohm and 0.2 A in 6 ohm

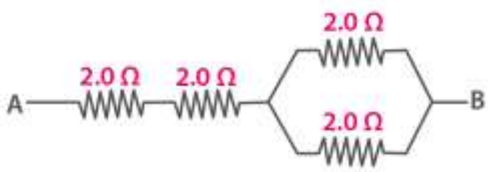
32. **A particular resistance wire has a resistance of 3 ohm per meter. Find:**
(a) The total resistance of three lengths of this wire each 1.5 m long, in parallel.
(b) The potential difference of the battery which gives a current of 2 A in each of the 1.5m length when connected in the parallel to the battery (assume that resistance of the battery is negligible).
(c) The resistance of 5 m length of a wire of the same material, but with twice the area of cross section.
Ans. (a) Resistance of wire per meter = 3 ohm
So, resistance of three lengths of this wire each 1.5 m long = 3 × 1.5 = 4.5 W
1 / R = 1 / 4.5 + 1 / 4.5 + 1 / 4.5
1 / R = 3 / 4.5
R = 1.5 ohm
(b) I = 2 A
V = IR
V = 2 × 4.5
V = 9 V
(c) R = 3 ohm for 1 meter wire
For 5 m
R = 3 × 5
R = 15 ohm
Here the area is twice i.e 2 A and Resistance is inversely proportional to area. Thus resistance becomes half
R = 15 / 2
R = 7.5 ohm

33. **A battery of e.m.f. 3.0 V supplies current through a circuit in which resistance can be changed. A high resistance voltmeter is connected across the battery. When the current is 1.5 A, the voltmeter reads 2.7 V. Find the internal resistance of the battery.**
Ans. Given
ε = 3 volt
I = 1.5 A
V = 2.7 V
V = ε – Ir
r = (e – V) / I
r = (3 – 2.7) / 1.5
r = 0.2 ohm

34. **A circuit consists of a 1 ohm resistor in series with a parallel arrangement of 6 ohm and 3 ohm resistors. Calculate the total resistance of the circuit. Draw a diagram of the arrangement.**
Ans. 1 / r = 1 / 6 + 1 / 3
1 / r = 1 / 2
r = 2 ohm
R = 2 + 1
R = 3 ohm

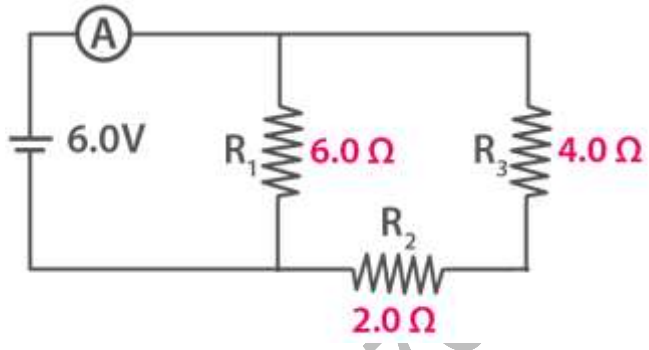


35. **Calculate the equivalent resistance between the points A and B in figure if each resistance is 2.0 Ω**
Ans. For a parallel resistance
$R_{eff} = (R_1R_2) / (R_1 + R_2)$
$R_{eff} = (2 \times 2) / (2 + 2)$
$R_{eff} = 4 / 4$
$R_{eff} = 1\ \Omega$
Hence, total resistance = 2 + 2 + 1 = 5



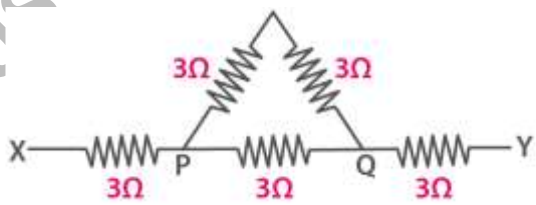
36. **Three resistors of 6.0-ohm, 2.0 ohm and 4.0 ohm are joined to an ammeter A and a cell of emf 6.0 V as shown in figure. Calculate:**
(a) the effective resistance of the circuit.
(b) the reading of ammeter

Ans. (a) $R_1 = 6$ W
$R' = R_2 + R_3$
$R' = 2 + 4$
$R' = 6$ W
R_1 and R' are connected in parallel
$1 / R = 1 / R_1 + 1 / R'$
$1 / R = 1 / 6 + 1 / 6$
$1 / R = 2 / 6$
$1 / R = 1 / 3$
R = 3 ohm
(b) R = 3 ohm
V = 6 V
I =?
I = V / R
I = 6 / 3
I = 2 A



37. **Five resistors, each of 3 ohm, are connected as shown in figure. Calculate the resistance (a) between the points P and Q, and (b) between the points X and Y.**

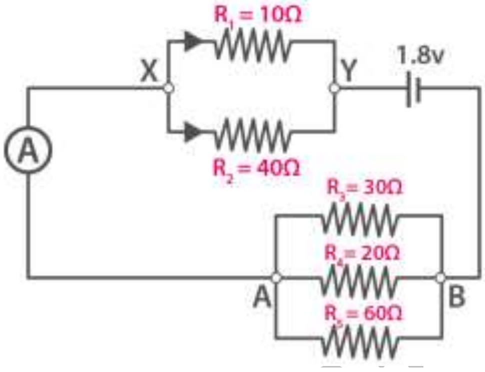
Ans. (a) $R_1 = 3 + 3$
$R_1 = 6$ ohm
$R_2 = 3$ ohm
R_1 and R_2 are connected in parallel
$1 / R = 1 / R_1 + 1 / R_2$
$1 / R = 1 / 6 + 1 / 3$
$1 / R = (1 + 2) / 6$
$1 / R = 3 / 6$
$1 / R = 1 / 2$
R = 2 ohm
(b) We know that R = 2 ohm from the above calculation
$R_3 = 3$ ohm
$R_4 = 3$ ohm
$R' = R + R_3 + R_4$
$R' = 2 + 3 + 3$
R' = 8 ohm



38. The diagram below in Fig., shows the arrangement of five different resistances connected to a battery of e.m.f. 1.8 V. Calculate:

a. The total resistance of the circuit

b. The reading of ammeter A.



Ans. (a) In the above figure,

Let R_{XY} be the resistance between X and Y

Then, $1 / R_{XY} = 1 / 10 + 1 / 40$

$1 / R_{XY} = (4 + 1) / 40$

$1 / R_{XY} = 5 / 40$ ohm

Or $R_{XY} = 8$ ohm

Let the net resistance between points A and B be R_{AB}

Then, $1 / R_{AB} = 10$ ohm

∴ The total resistance of the circuit = 8 ohm + 10 ohm = 18 ohm

(b) Current I = Voltage / Total resistance

$I = 1.8 / 18$ A

$I = 0.1$ A

Hence, the reading of ammeter is 0.1 A

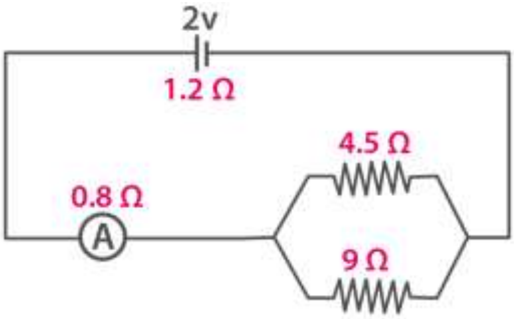
39. A cell of e.m.f. 2 V and internal resistance 1.2 Ω is connected to an ammeter of resistance 0.8 Ω and two resistors of 4.5 Ω and 9 Ω as shown in fig.

Find:

(a) The reading of the ammeter,

(b) The potential difference across the terminals of the cells, and

(c) The potential difference across the 4.5 ohm resistor.



Ans. The total resistance of the circuit is

$R_{eq} = R_{cell} + R_{ammeter} + R_1 || R_2$

$\therefore R_{eq} = 1.2 + 0.8 + (R_1R_2) / R_1 + R_2$

$\therefore R_{eq} = 2 + (4.5 \times 9) / 4.5 + 9$

$R_{eq} = 2 + 40.5 / 13.5$

$\therefore R_{eq} = 5$ ohm

(a) The current through the ammeter is

$I = E_{cell} / R_{eq}$

$I = 2 / 5$

$I = 0.4$ A

(b) The potential difference across the ends of the cells is

$V_{cell} = E_{cell} - IR_{cell}$

$V_{cell} = 2 - 0.4 \times 1.2$

$V_{cell} = 2 - 0.48$

$\therefore V_{cell} = 1.52$ V

(c) The potential difference across the 4.5 ohm resistor is

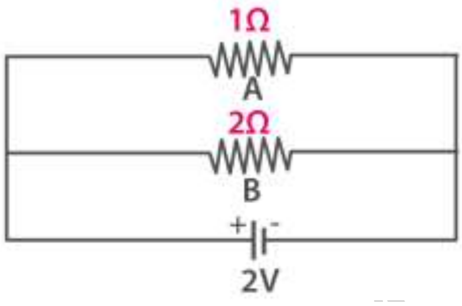
$V_{4.5} = V_{cell} - V_{ammeter}$

$V_{4.5} = 1.52 - 0.4 \times 0.8$

$V_{4.5} = 1.52 - 0.32$

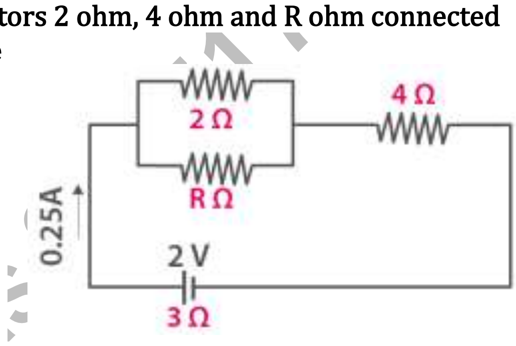
$\therefore V_{4.5} = 1.2$ V

40. Calculate the current flowing through each of the resistors A and B in the circuit shown in figure?



Ans. For resistor A
R = 1 ohm
V = 2 V
I = V / R
I = 2 / 1
I = 2 A
For resistor B
R = 2 ohm
V = 2 V
I = V / R
I = 2 / 2
I = 1 A
Hence, current flowing in resistor A is 2 A and current flowing in resistor B is 1 A

41. The circuit diagram in figure shows three resistors 2 ohm, 4 ohm and R ohm connected to a battery of e.m.f. 2 V and internal resistance 3 ohm. If main current of 0.25 A flows through the circuit, find:
(a) the p.d. across the 4 ohm resistor
(b) the p.d. across the internal resistance of the cell,
(c) the p.d. across the R ohm or 2 ohm resistor, and
(d) the value of R.



Ans. (a) To calculate the p.d. across the 4-ohm resistor
R = 4 ohm
I = 0.25 A
V = IR
V = 0.25 × 4
V = 1 V
(b) To calculate the p.d. across the internal resistance of the cell
Internal resistance r = 3 ohm
I = 0.25 A
V = IR
V = 0.25 × 3=0.75V
(c) To calculate the p.d. across the 2 ohm resistor
Effective resistance of parallel combination of 2 ohm resistances = 1 ohm
V = I / R
V = 0.25 / 1
V = 0.25 V
(d) To calculate the value of R
I = 0.25 A
ε = 2 V
r = 3 ohm
ε = I (R' + r)
2 = 0.25 (R' + 3)
R' = 5 W
[2R / 2 + R] + 4 = 5
R = 2 ohm

42. A battery of emf 15 V and internal resistance 3 ohm is connected to two resistors 3 ohm and 6 ohm connected in parallel. Find (a) the current through the battery (b) p.d. between the terminals of the battery (c) the current in 3 ohm resistor (d) the current in 6 ohm resistor.

Ans. (a) In parallel
$1 / R = 1 / 3 + 1 / 6$
$1 / R = (2 + 1) / 6$
$1 / R = 3 / 6$
$1 / R = 1 / 2$
$R = 2$ ohm
$r = 3$ W
$\varepsilon = 15$ V
$\varepsilon = I (R + r)$
$15 = I (2 + 3)$
$I = 15 / 5=3A$

(b) $R = 2$ ohm
$V = IR$
$V = 3 \times 2$
$V = 6$ V
(c) $V = 6$ V
$R = 3$ ohm
$I = V / R$
$I = 6 / 3$
$I = 2$ A
(d) $R = 6$ ohm
$V = 6$ V
$I = V / R$
$I = 6 / 6=1A$

43. A cell supplies a current of 1.2 A through two 2 ohm resistors connected in parallel. When resistors are connected in series, it supplies a current of 0.4 A. Calculate: (i) the internal resistance and (ii) e.m.f. of the cell.

Ans. In parallel $R = 1 / 2 + 1 / 2 = 1$ ohm
$I = 1.2$ A
$\varepsilon = I (R + r)$
$\varepsilon = 1.2 (1 + r)$
$\varepsilon = 1.2 + 1.2r$
In series
$R = 2 + 2$
$R = 4$ ohm
$I = 0.4$ A
$\varepsilon = I (R + r)$
$\varepsilon = 0.4 (4 + r)$
$\varepsilon = 1.6 + 0.4r$
This means:
$1.2 + 1.2r = 1.6 + 0.4r$
$1.2r – 0.4r = 1.6 – 1.2$
$0.8r = 0.4$
$r = 0.4 / 0.8$
$r = 0.5$ ohm
(i) Internal resistance $r = 0.5$ ohm
(ii) $\varepsilon = I(R + r)$
$\varepsilon = 1.2 (1 + 0.51.8$ V

44. An electric bulb of resistance 500 ohm draws current 0.4 A from the source. Calculate: (a) the power of bulb and (b) the potential difference at its end.

Ans. Given
Resistance of electric bulb (R) = 500 ohm
Current drawn from the source (I) = 0.4 A
(a) Power of the bulb (P) = VI
$V = I \times R$
$V = 0.4 \times 500$
V = 200 V
(b) The potential difference at its end is 200 V
Therefore,
Power (P) = VI
$P = 200 \times 0.4 = 80$ W
Hence, the power of the bulb is 80 Watt

45. A current of 2 A is passed through a coil of resistance 75 Ω for 2 minutes. (a) How much heat energy is produced? (b) How much charge is passed through the resistance?

Ans. Given,
Current (I) = 2 A
Resistance, R = 75 Ω
Time, t = 2 min or 120 s
(a) Heat produced, $H = I^2Rt$ or
$H = (2)^2 (75) (120)$ J = 36000 J
(b) Charge passed through the resistance, Q = It or
Q = (2) (120) C = 240 C

46. Calculate the current through a 60 W lamp rated for 250 V. If the line voltage falls to 200 V, how is power consumed by the lamp affected?

Ans. Given,
Power, P = 60 W
Voltage, V = 250 V
We know that,
Power, P = VI
I = P / V = 60 / 250 = 0.24 A
Resistance of lamp $R = V^2 / P$
$R = (250)^2 / 60 = 1041.6$ ohm
If voltage falls to 200 V, then the power consumed will be
$P = V^2 / R = (200)^2 / 1041.6 = 38.4$ W
Hence, consumed reduces to 38.4 W

47. An electric press is rated '750 W, 230 V'. Calculate the electrical energy consumed by the press in 16 hours

Ans. Energy, $E = \text{Power} \times \text{time}$
$E = 750 \times 16$
E = 12000 Wh = 12 kWh

48. A bulb of power 40 W is used for 12.5 h each day for 30 days. Calculate the electrical energy consumed.

Ans. Energy consumed for each day, $E = P \times t$
$E = 40 \times 12.5 = 500$ Wh
Energy consumed for 30 days
$E = 500 \times 30$
E = 15000 Wh = 15 kWh

49. An electric bulb is rated '100 W, 250 V'. How much current will the bulb draw if connected to a 250 V supply?

Ans. Given,
Power, P = 100 W
Voltage, V = 250 V
We know that,
Power, P = VI
I = P / V
I = 100 / 250 = 0.4 A

50. An electric bulb is rated at 220 V, 100 W. (a) What is its resistance? (b) What safe current can be passed through it?

Ans. (a) Given,
Power, P = 100 W
Voltage, V = 220 V
We know that,
Power, P = V^2 / R
R = $(220)^2$ / 100
R = 484 ohm
(b) The safe limit of current that can be passed through it is
I = P / V
I = 100 / 220 = 0.45 A

51. An electrical appliance having a resistance of 200 ohm is operated at 200 V. Calculate the energy consumed by the appliance in 5 minutes (i) in joule, (ii) in kWh

Ans. Given,
Resistance, R = 200 ohm
Voltage, V = 200 V
Time, t = 5 minutes
t = 5 × 60 sec
t = 300 sec
As we know,
Energy, E = V^2t / R
(i) In joules
E = [$(200)^2$ × 300] / 200
E = 60000 J
(ii) In kWh
As 1 kWh = 3.6 × 10^6 J
1 J = 1 / 3.6 × 10^6 kWh
60000 J = 60000 / 3.6 × 10^6
60000 J = 0.0167 kWh

52. A bulb rated 12 V, 24 W operates on a 12 volt battery for 20 minutes. Calculate: (i) the current flowing through it, and (ii) the energy consumed.

Ans. Given,
Power, P = 24 W
Voltage, V = 12 V
Current, I =?
We know that,
Power, P = VI
(i) The current flowing through it is
I = 24 / 12 = 2 A
(ii) Energy, E = P × t
E = 24 × 20 × 60 = 28,800 J

53. A current of 0.2 A flows through a wire whose ends are at a potential difference of 15 V. Calculate: (i)The resistance of the wire, and (ii)The heat energy produced in 1 minute.

Ans. Given,
Current, $I = 0.2$ A
Potential difference, $V = 15$ V
Time, $t = 60$ sec
As $V = IR$
(a) To calculate the resistance of the wire
$R = V / I = 15 / 0.2 = 75$ ohm
(b) To calculate the heat energy produced in 1 minute
Heat energy, $H = I^2Rt$
$H = (0.2)^2 \times 75 \times 60 = 180$ J

54. What is the resistance, under normal working conditions, of an electric lamp rated at '240 v', 60 W? If two such lamps are connected in series across a 240 V mains supply, explain why each one appears less bright.

Ans. Given,
Voltage, $V = 240$ V
Power, $P = 60$ W
We know that,
$P = V^2 / R$
$R = V^2 / P$
$R = (240)^2 / 60 = 960$ ohm
$I = P / V$
$I = 60 / 240 = 0.25$ A
Thus, when one lamp is connected across the mains, it draws 0.25 A current. If two such lamps are connected in series across the mains, current through each bulb becomes [240 / (960 + 960) ohm] = 0.125 A (i.e., current is halved.) Hence, heating (= I^2Rt) in each bulb becomes one fourth, so each bulb appears less bright.

55. Water in an electric kettle connected to a 220 V supply took 5 minutes to reach its boiling point. How long will it take if the supply had been of 200 V?

Ans. $P = V^2 / R$
Heat gained = $(V^2 / R) \times t$
$(V_1^2 / R) \times t_1 = (V_2^2 / R) \times t_2$
$t_2 = (V_1 / V_2)^2 \times t_1$
$t_2 = (220 / 200)^2 \times 300$
$t_2 = 363$ s = 6.05 min

56. Two bulbs are rated 60 W, 220 V and 60 W, 110 V, respectively. Calculate the ratio of their resistances.

Ans. Given,
Voltage, $V_1 = 220$ V
$V_2 = 110$ V
Power, $P_1 = P_2 = P = 60$ W
We know that, $R = V^2 / P$
$R_1 = V_1^2 / P$
$R_1 = (220)^2 / 60$
$R_2 = V_2^2 / P$
$R_2 = (110)^2 / 60$
Now, dividing R_1 and R_2 we get,
$R_1 / R_2 = [(220)^2 / 60] / [(110)^2 / 60]$
$R_1 / R_2 = 4 / 1$
$R_1 : R_2 = 4 : 1$

57. **An electric bulb is rated 250 W, 230 V. (i) the energy consumed in one hour, and (ii) the time in which the bulb will consume 1.0 kWh energy when connected to 230 V mains?**

Ans. Given,
Power, P = 250 W
Voltage, V = 230 V
(i) Energy, $E = P \times t$
Time, $t = 1 \times 60 \times 60$
t = 3600 sec
We know that,
$E = 250 \times 3600$
$E = 9 \times 10^5$ J
(ii) 1000 Wh = $250 \times t$
time, t = 1000 / 250 = 4 hours

58. **Three heaters each rated 250 W, 100 V are connected in parallel to a 100 V supply. Calculate: (i)The total current taken from the supply, (ii)The resistance of each heater, and (iii)The energy supplied in kWh to the three heaters in 5 hours.**

Ans Given,
Power, P = 250 W
Voltage, V = 100 V
(i) Current through each heater, I =?
As P = VI
I = P / V
I = 250 / 100 = 2.5 A
∴ Current taken for the three heaters = $3 \times 2.5 = 7.5$ A
(ii) Resistance for each heater, R = V / I
R = 100 / 2.5
R = 40 ohm
(iii) Time for which energy is supplied, t = 5 h
Energy, $E = P \times t$
$E = 250 \times 5$
E = 1250 Wh = 1.25 kWh
Energy for three heaters = $3 \times 1.25 = 3.75$ kWh

59. **An electric toaster draws current 8 A in a circuit with source of voltage 220 V. It is used for 2 h. Find the cost of operating the toaster if the cost of electrical energy is ₹ 4.50 per kWh**

Ans. Given,
Voltage, V = 220 V
Current, I = 8 A
Time, t = 2 h
Energy, E = VIt
$E = 220 \times 8 \times 2$
E = 3520 Wh
E = 3.52 kWh
Cost of energy = ₹ 4.50 per kWh
∴ Cost of 3.52 kWh of energy = ₹ 4.50 × 3.52 kWh = ₹ 15.84

60. **A bulb is connected to a battery of p.d. 4 V and internal resistance 2.5 ohm. A steady current of 0.5 A flows through the circuit. Calculate: (i)The total energy supplied by the battery in 10 minutes, (ii)The resistance of the bulb, and (iii)The energy dissipated in the bulb in 10 minutes.**
Ans. Given,
Voltage, $V = 4$ V
Resistance of the battery, $R_B = 2.5$ ohm
Current, $I = 0.5$ A
(i) Energy supplied by the battery, $E = V^2t / R$
$t = 10 \times 60$
$t = 600$ sec
$R = V / I$
$R = 4 / 0.5$
$R = 8$ ohm
$E = [(4)^2 \times 600] / 8 = 1200$ J
(ii) Total resistance, $R = 8$ ohm
Resistance of the battery, $R_B = 2.5$ ohm
Resistance of the bulb, $R_b = 8 - 2.5$ ohm
$R_b = 5.5$ ohm
(iii) Energy dissipated in the bulb in 10 min, $E = I^2Rt$
$E = (0.5)^2 \times 5.5 \times 600 = 825$ J

61. **Two resistors A and B of 4 ohm and 6 ohm, respectively are connected in parallel. The combination is connected across a 6 volt battery of negligible resistance. Calculate: (i) the power supplied by the battery, (ii) the power dissipated in each resistor.**
Ans. Given,
Resistance, $R_A = 4$ ohm
Resistance, $R_B = 6$ ohm
Voltage, $V = 6$ V
(i) Since the resistances are connected in parallel
Equivalent Resistance, $1 / R = 1 / R_A + 1 / R_B$
$1 / R = 1 / 4 + 1 / 6 = 10 / 24 = 2.4$ ohm
We know that,
Power, $P = V^2 / R$
$P = (6)^2 / 2.4 = 15$ W
(ii) Power dissipation across each resistor, $P = VI$
Current across resistor R_A, $I_A = V / R_A$
$I_A = 6 / 4 = 1.5$ A
Power dissipation across resistor R_A,
$P = VI_A = 6 \times 1.5 = 9$ W
(iii) Current across resistor R_B, $I_B = V / R_B$
$I_B = 6 / 6 = 1$ A
Power dissipation across resistor R_B,
$P = VI_B = 6 \times 1 = 6$ W

62. **An electric kettle is rated 2.5 kW, 250 V'. Find the cost of running the kettle for two hours at ₹ 5.40 per unit.**
Given,
Power of kettle, $P = 2.5$ kW
Voltage, $V = 250$ V
Time, $t = 2$ h
As, Energy, $E = P \times t = 2.5 \times 2 = 5$ kWh
Cost per unit of energy = ₹ 5.40
Cost for 5 kWh of energy = 5.40×5 = ₹ 27

63. A battery of e.m.f. 15 V and internal resistance 2 ohm is connected to two resistors of resistances 4 ohm and 6 ohm joined in series. Find the electrical energy spent per minute in 6-ohm resistor.

Ans. Given,
e.m.f. of battery, V = 15 V
Internal resistance of battery, R_B = 2 ohm
Resistances given in circuit,
R_1 = 4 ohm and R_2 = 6 ohm
(i) When resistors are connected in series,
Equivalent resistance, $R = R_B + R_1 + R_2$
R = 12 ohm
Current in the circuit, I = 15 / 12
I = 1.25 A
Now,
Voltage across resistor R_2, $V_2 = IR = 1.25 \times 6$
$V_2 = 7.50$ V
Time, t = 1 min = 60 sec
Energy across R_2, $E = V^2t / R$
$E = [(7.5)^2 \times 60] / 6 = 562.5$ J

64. A geyser is rated 1500 W, 250 V. This geyser is connected to 250 V mains. Calculate: (i)The current drawn, (ii)The energy consumed in 50 hours, and (iii)The cost of energy consumed at ₹ 4.20 per kWh.

Ans. Given,
Power of geyser, P = 1500 W
Voltage, V = 250 V
(i) Current, I = P / V
I = 1500 / 250 = 6 A
(ii) Time, t = 50 h
Energy, $E = P \times t$
$E = 1500 \times 50$
E = 75000 Wh = 75 kWh
(iii) Cost per unit of energy = ₹ 4.20
Cost for 75 kWh of energy = 4.20×75 = ₹ 315

Sourav K