Electricity

Solved Intext Exercises

Q1. What does an electric circuit mean?

Sol. A continuous and closed path of an electric current is called an electric circuit.

Q2. Define the unit of current.

Sol. The unit of current is Ampere. Electric current through a conductor is said to be 1 Ampere if one Coulomb charge flows through any cross-section of the conductor in one second.

Q3. Calculate the number of electrons constituting one coulomb of charge.

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

$1.6 \times 10^{-19}\, C$ of charge is in = 1 electron

Therefore, 1 C of Charge is on $= \frac{1}{1.6 \times 10^{-19}}\, C \times 1\, C = 6.25 \times 10^{18}$

Thus, 6.25×10^{18} electrons constitute one coulomb of charge.

Q4. Name a device that helps to maintain a potential difference across a conductor.

Sol. Battery is a device which maintained P.D. across the ends of conductor.

Q5. What is meant by saying that the potential difference between two points is 1V?

Sol. The potential difference between two points 1 volt is one joule of work is done in bringing a one coulomb charge from one point to the other point in the electric field.

Q6. How much energy is given to each coulomb of charge passing through a 6V battery?

Sol. Given Charge, $Q = 1\, C;\ V = 6V$

Work done (energy) = W

We know, $V = \frac{W}{Q}$

therefore, $W = V \times Q = 6\, V \times 1\, C = 6\, J$

6J of energy is given to each coulomb of charge passing through a 6V battery.

Q7. On what factors does the resistance of a conductor depends?

Sol. The resistance of a conductor depends upon the following factors:

- The resistance of a conductor is directly proportional to its length.
- The resistance of a conductor is inversely proportional to its area of cross-section.
- The resistance of a conductor also inversely proportional to the square of the diameter of the conductor.
- The resistance of a conductor depends upon the nature of the material of the conductor.
  For example: Nichrome alloy has 60 times resistance then copper metal of similar length and area of cross section.
- The resistance of the conductor depends upon the temperature of conductor.

For example:

- The resistance of pure metal always increases with rise in temp and vice - versa, that means resistance of a pure metal is directly proportional to the change in temperature.
- Resistance of metallic alloys like, german silver, mangning, constantan and nichrome slightly directly proportional to the change in temperature.
- The resistance of semi conductors like silicon, germanium, etc are decreases on increase increasing the temperature.

Q8. Will current flow more easily through a thick wire or a thin wire of the same material, when connected to the same source? Why?

Sol. Current will flow more easily through a thick wire of the same material, when connected to the same source this is because resistance is inversely proportional to the area of cross-section of the conductor. Hence when area of cross-section is increased, the resistance decreases and as result current flows more easily.

Q9. Let the resistance of an electrical component remains constant while the potential difference across the two ends of the com ponent decreases to half of its former value. What change will occur in the current through it.

Sol. If the potential difference across the two ends of the component decreases to half of its former value then the current will also decrease to half of its former value because potential difference is directly proportional to current.

Q10. Why are coils of electric toasters and electric irons made of an alloy rather than a pure metal?

Sol. The coils of electric toasters and electric irons made of an alloy rather than a pure metal because the resistivity of an alloy is higher than that of pure metals and they do not burn (oxides) readily at high temperature.

Q11. Use the data in Table 12.2 of (Textbook) to answer the following:

(a) Iron is a better conductor.

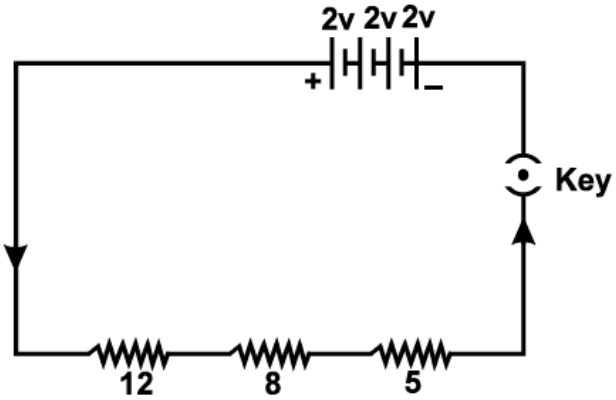
(b) Which material is the best conductor?

Sol. (a) Iron is a better conductor.

(b) Silver is the best conductor.

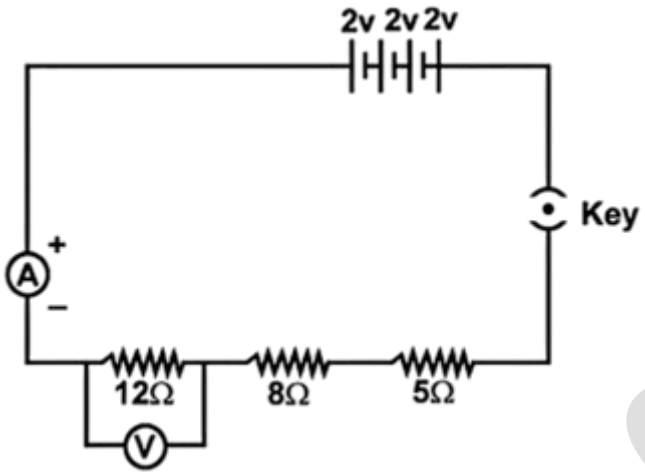
Q12. Draw a schematic diagram of a circuit constituting of a battery of three cells and 2V each, a 5 ohm resistor, an 8 ohm resistor, and a 12 ohm resistor, and a plug key, a all connected in series.

Sol.



Q13. Redraw the circuit of above question, putting in an ammeter to measure the current through the resistor and a voltmeter to measure the potential difference across the 12 ohm resistor. What would be the readings in the ammeter and the voltmeter?

Sol.



Total voltage supplied, V = 3 × 2 = 6V

Total resistance, of the circuit is given by

R = 5 + 8 + 12 = 25 ohm.

Current, I = ?

We know that, I = V/R = 6 V / 25 ohm = 0.24 A

Reading in the ammeter = 0.24 A

Reading in voltmeter V = IR = 0.24 × 12 = 2.88 V

Q14. Judge the equivalent resistance when the following are connected in parallel (a) 1 ohm and 106 ohm (b) 1 ohm and 103 ohm and 106 ohm.

Sol. (a) Equivalent resistance is less than 1 ohm.

(b) Equivalent resistance is less than 1 ohm.

Q15. An electric lamp of 100 ohm, a toaster of resistance 50 ohm, and a water filter resistor 500 ohm are connected in parallel to a 220V sources. What is the resistance of an electric iron connected to the same source that takes as much current as all the three appliances, and what is the current through it ?

Sol. Given,

Resistance of electric lamp, R_1 = 100 ohm.

Resistance of toaster, R_2 = 50 ohm

Resistance of water filter, R_3 = 50 ohm

Resultant Resistance, R = ?

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

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

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

$$\frac{1}{R} = \frac{16}{500}\ ohm$$

$$R = \frac{500}{16}\ ohm$$

Resistance of electric iron is 500/16 ohm

Current through electric iron, I = ?

$R = 500/16\ ohm\ ;\ V = 200\ V$

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

$$= \frac{200}{\frac{500}{16}}$$

$$= 220 \times \frac{16}{500}$$

$$= 7.04\ A$$

Q16. What are the advantage of connecting electrical devices in parallel with the battery instead of connecting them in series?

Sol.

(i) In parallel circuits, if one electrical appliances stops working due to some defect, then all other appliances keep working normally.

(ii) In parallel circuits, each electrical appliance has its own switch due to which it can turned on or turned off independently, without affecting other appliances.

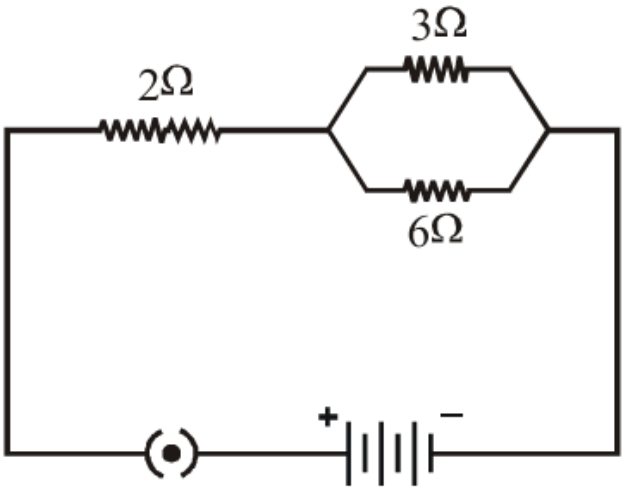
(iii) In parallel circuits, each electrical appliance gets the same voltage (220V) as that of the power supply line due to this each resistance work properly.

(iv) In the parallel connection of electrical appliances, the overall resistance of the household circuit is reduced due to which the current from the power supply is high.

Q17. How can three resistors of resistance 2 ohm, 3 ohm, and 6 ohm be connected to give a total resistance of (a) 4 ohm, (b) 1 ohm?

Sol. (a) To obtain a total resistance of 4 ohm.

we connect 3 ohm and 6 ohm resistances in parallel and then connect 2 ohm resistance in series.



$$\frac{1}{R'} = 1/3 + \frac{1}{6}$$

$$\frac{1}{R'} = 2 + \frac{1}{6}$$

$$\frac{1}{R'} = \frac{3}{6}$$

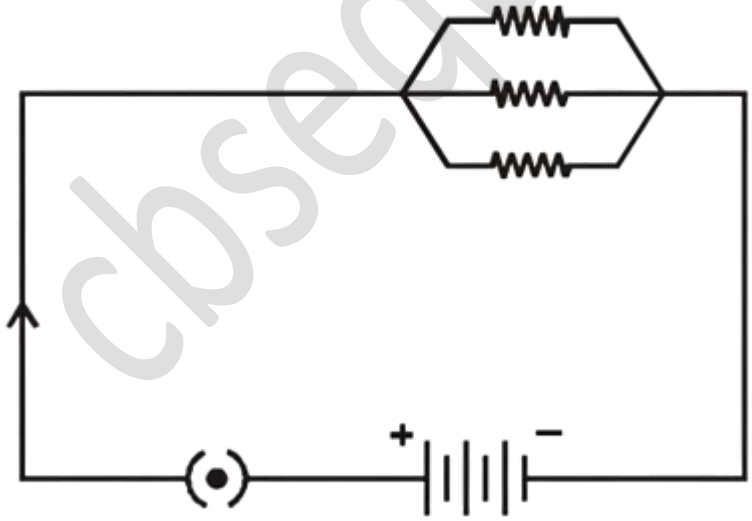
$$R' = \frac{6}{3}$$

$$R' = 2\,ohm$$

$$R = R' + 2\,ohm = 2\,ohm + 2\,ohm = 4\,ohm$$

(b) To obtain a total resistance of 1 ohm.

we connect three resistors of resistance 2 ohm, 3 ohm and 6 ohm in parallel.



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

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

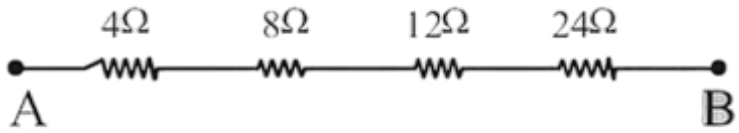
$$\frac{1}{R} = \frac{6}{6}$$

$$R = 1\ ohm$$

Q18. What is (i) the highest and, (ii) the lowest total resistance that can be secured by combinations of four coils of resistance 4 ohm, 8 ohm, 12 ohm, 24 ohm ?

Sol.

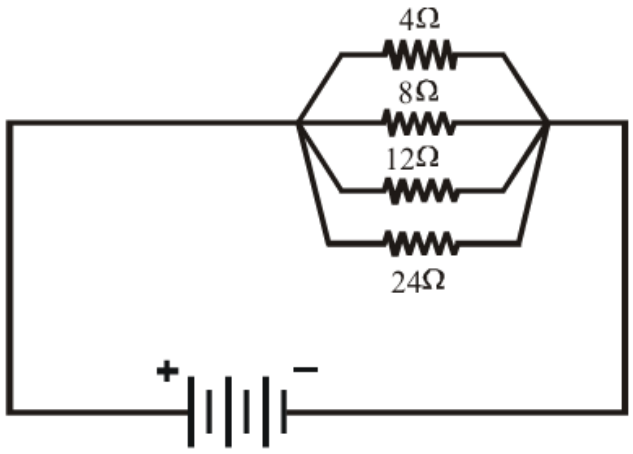
(a) Highest total resistance can be secured by contribution of four coils of resistance 4 ohm, 8 ohm, 12 ohm, 24 ohm in series.



$$R = R_1 + R_2 + R_3 + R_4$$

$$R = 4 + 8 + 12 + 24 = 48\ ohm$$

(b) Lowest total resistance can be secured by combination of four coils of resistance 4 ohm, 8 ohm, 12 ohm, 24 ohm in parallel.



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

$$\frac{1}{R} = \frac{1}{4} + \frac{1}{8} + \frac{1}{12} + \frac{1}{24}$$

$$\frac{1}{R} = \frac{6+3+2+1}{24}$$

$$\frac{1}{R} = \frac{12}{24}$$

$$R = 2\ ohm$$

Q19. Why does the cord of an electric heater not glow while the heating element does?

Sol. The heating element and cord of an electric heater carry same current but the heating element becomes hot due to its high resistance ($H = I^2RT$) and cord remain cold due to their low resistance.

Q20. Compute the heat generated while transferring 96000 coulomb of charge in one hour through a potential difference of 50V.

Sol. Given, Charge, Q = 96000C ; Current, I =? Time, t =1 hour = 3600 s

$$I = \frac{Q}{t} = \frac{96000\ C}{3600\ s} = 26.67\ A$$

Heat generated,

$$H = VIt = 50 \times 26.67 \times 3600$$

$$= 4800000\ J$$

$$= 4.8 \times 10^6\ J$$

Q21. An electric iron of resistance 20 ohm takes a current of 5A. Calculate the heat developed in 30s.

Sol. R = 20 ohm ; I = 5A ; t = 30s

Heat produced, H = ?

We know that, $H = I^2RT$

$= 5A \times 5A \times 20\ ohm \times 30s$

$= 1500\ J = 1.5 \times 10^4\ J$

Q22. What determines the rate at which energy is delivered by a current ?

Sol. Electric power.

Q23. An electric motor takes 5A from a 220V line. Determine the power of the motor and the energy consumed in 2h.

Sol. I = 5A, V = 220V, P = ?, E = ?

$$P = V \times I = 220 \times 5A = 1100\ W$$

Total energy consumed in 2 Hr is given by

$$E = P \times t = 1.1 \times 2 = 2.2\ kwh$$

Solved NCERT Exercises

Q1. 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 then the ratio R/R' is —

(a) 1/25

(b) 1/5

(c) 5

(d) 25

Ans : (d)

Q2. Which of the following terms does not rep resent electrical power in a circuit ?

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

Ans :(b)

Q3. An electric bulb is rated 220V and 100W. When it is operated on 110V, the power consumed will be—

(a) 100W

(b) 75W

(c) 50W

(d) 25W

Ans : (d)

Sol. We know that

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

$$R = \frac{V^2}{P} = \frac{2202}{100} = \frac{48400}{100} = 484\ ohm$$

$$P = \frac{V^2}{R} = \frac{1102}{484} = \frac{12100}{484} = 25\ W$$

Q4. Two conducting wires of the same material and of equal lengths and equal 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 : (d)

Sol. When they are connected in series then their combined resistances is given by

R = 2x ohm

$$H_1 = \frac{V^2 t}{2x}$$

When they are connected in parallel then their combined resistances 'R' are given by

$$\frac{1}{R} = \frac{1}{x} + \frac{1}{x}$$

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

$$R = \frac{x}{2}\ ohm$$

$$H_2 = \frac{V^2 t}{\frac{x}{2}}$$

$$H_2 = \frac{2V^2 t}{x}$$

Required ratio

$$\frac{H_1}{H_2} = \frac{\frac{V^2 t}{2x}}{\frac{2V^2 t}{x}} = \frac{1}{4} = 1 : 4$$

Q5. How is a voltmeter connected in the circuit to measure the potential difference between two points?

Sol. To measure the potential difference between two points voltmeter is connected parallel in the circuit.

Q6. A copper wire has diameter 0.5mm and resistivity of 1.6×10^{-8} ohm m. What will be the length of this wire to make its resistance 10 ohm ? How much does resistance change if the diameter is doubled?

Sol.

Q7. The values of current I flowing in a given resistor for the corresponding values of potential difference V across the resistor are given below—

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

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

Sol.

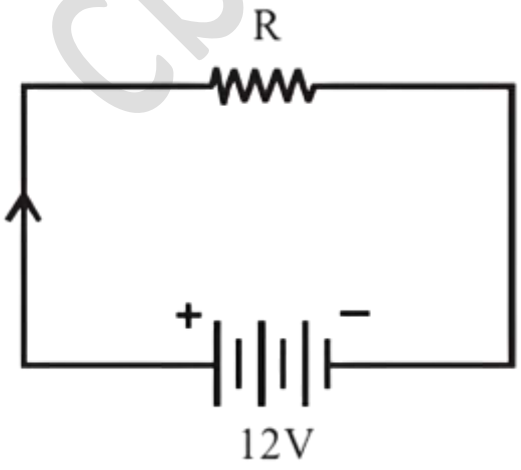
Q8. When a 12V battery is connected across an unknown resistor, there is a current of 2.5mA in the circuit. Find the value of the resistance of the resistor.

Sol. V = 12V ; I = 2.5mA = 0.0025A ; R = ?

We know that

$$R = \frac{V}{I} = \frac{12\ V}{0.0025\ A}$$

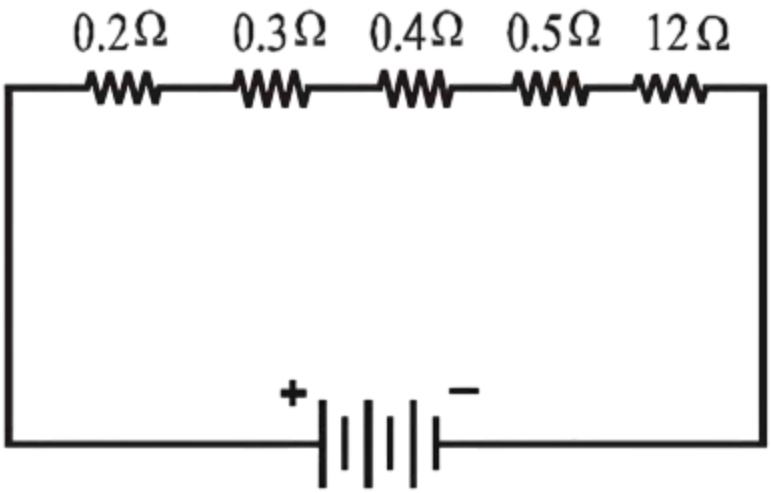
$$R = 4800\ ohm$$



Q9. A battery of 9V is connected in series with resistors of 0.2ohm, 0.3ohm, 0.4ohm, 0.5ohm and 12ohm respectively. How much current would flow through the 12ohm resistor?

Sol. $V = 9V$; $I = ?$

Total resistance, $R = 0.2 + 0.3 + 0.4 + 0.5 + 12\ ohm = 13.4\ ohm$



Since, The resistances are connected in series. Therefore, the value of current through each resistance will be some.

$$I = \frac{V}{R} = \frac{9}{13.4} = 0.67\ A$$

Q10. How many 176ohm resistor (in parallel) are required to carry 5A on a 220V line ?

Sol. $I = 5A$; $V = 220V$; $R = ?$

We know

$$R = \frac{V}{I} = \frac{220}{5} = 44\ ohm$$

Let the number of resistor required = n

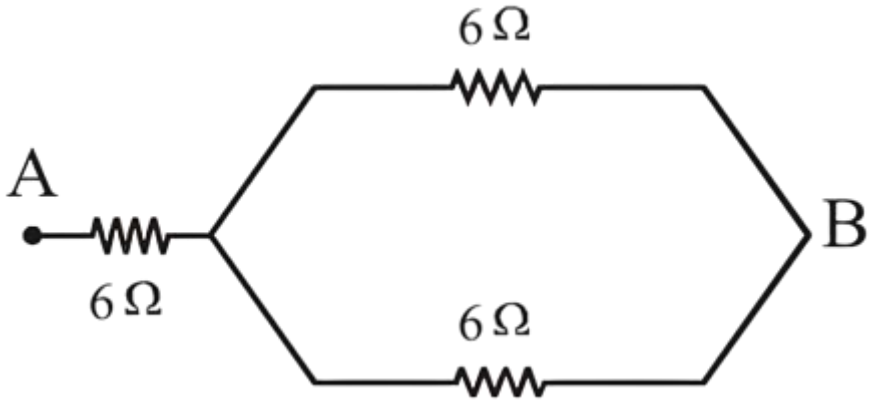
$$\frac{1}{44} = \frac{1}{176} + \frac{1}{176} + \frac{1}{176} + \ldots\ (n\ times)$$

$$\frac{1}{44} = \frac{n}{176}$$

$$n = \frac{176}{44} = 4$$

Q11. Show how you would connect three resistors, each of resistance 6ohm, that the combination has a resistance of (i) 9ohm (ii) 4ohm.

Sol. (i) To obtain 9 ohm resistance 2 resistors, each of resistance 6 ohm are connected in parallel and 6 ohm resistance connected in series

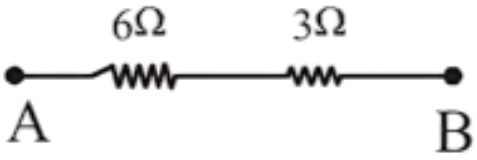


Equivalent resistance of connected in parallel is given by

$$\frac{1}{R'} = \frac{1}{6} + \frac{1}{6}$$

$$\frac{1}{R'} = \frac{1+1}{6}$$

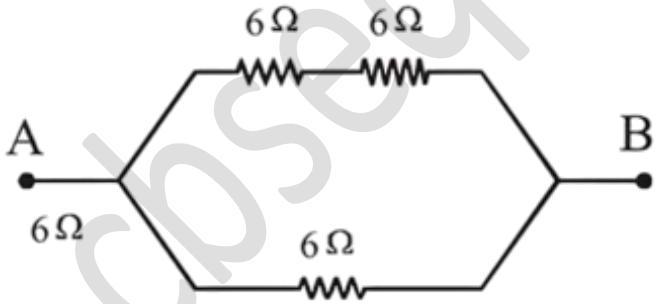
$$\frac{1}{R'} = \frac{2}{6} = 3\ ohm$$



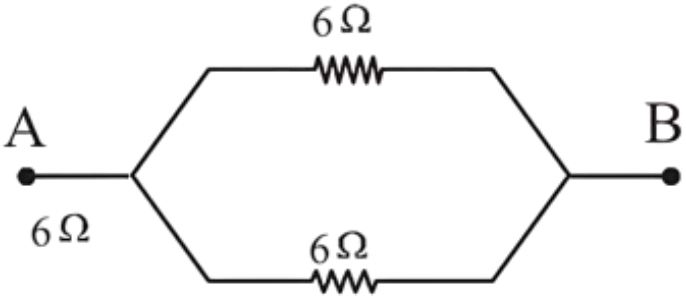
This combination in then connected in series with the resistance of 6ohm.

therefore, net resistance $R = 3 + 6 = 9\ ohm$

(ii) To obtain 4 ohm resistance, 2 resistance, each of resistance 6 ohm are connected in series then 6 ohm resistance connected in parallel



Equivalent resistance of 6ohm connect in series is given by



$$R = 6 + 6 = 12\ ohm$$

This combination is then connected in parallel with the resistance of 6ohm.

Therefore, Net resistance,

$$\frac{1}{R} = \frac{1}{12} + \frac{1}{6} = \frac{(1+2)}{12}$$

$$\frac{1}{R} = \frac{3}{12} = \frac{1}{4}$$

$$R = 4\ ohm$$

Q12. Several electric bulbs designed to be used on a 220V electric supply line, are rated 10W. How many lamps can be connected in parallel with each other across the two wires of 220V line if the maximum allow able current is 5A ?

Sol. Maximum Power $P = VI = 220\ V \times 5A = 1100\ W$

Number of bulbs $= \frac{1100\ W}{10} = 110\ bulbs$

Q13. A hot plate of an electric oven connected to a 220V line has two resistance coils A and B, each of 24ohm resistance, which may be used separately, in series, or in parallel. What are currents in the three cases?

Sol. (i) When resistance is used separately then

$$R = 24\ ohm\ ;\ V = 220\ V\ ;\ I = ?$$

We know,

$$I = \frac{V}{R} = \frac{220}{24} = 9.167A$$

(ii) When coils is in series then, resistance is given by

$$R = 24 + 24 = 48\ ohm$$

$$I = \frac{V}{R} = \frac{220}{48} = 4.58\ A$$

(iii) When resistance coils is in parallel then, combined resistance R is given by

$$\frac{1}{R} = \frac{1}{24} + \frac{1}{24}$$

$$\frac{1}{R} = \frac{1+1}{24}$$

$$\frac{1}{R} = \frac{2}{24}$$

$$R = 12ohm$$

$$I = \frac{V}{R} = \frac{220}{12} = 18.33A$$

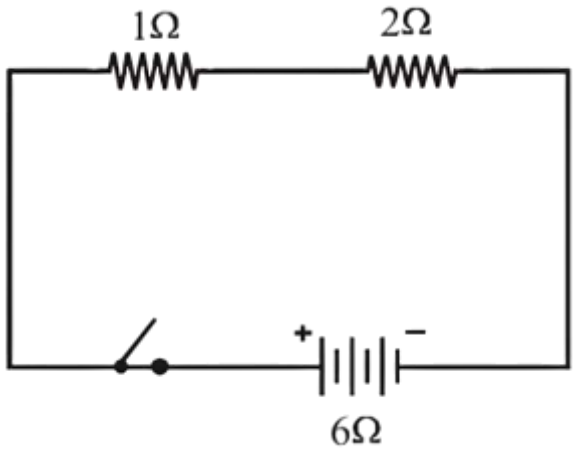
Q14. Compare the power used in the 2ohm resistor in each of the following circuit : (i) a 6V battery in series with 1ohm and 2ohm resistors, and (ii) a 4V battery in parallel with 12ohm and 2ohm resistors.

Sol. (i) V = 6V ; Current, I = ?

Resistance, $R = R_1 + R_2 = 1 + 2 = 3\ ohm$

We know

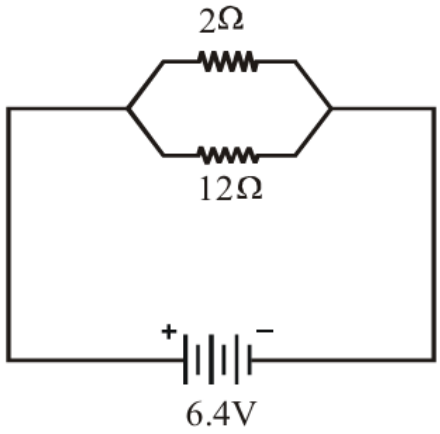
$$I = \frac{V}{R} = \frac{6}{3} = 2A$$



Current, I will be same in both resistors because they are connected in series.

Therefore, Power, $P = VI = 6V \times 2A = 12W$

(ii) In parallel connection current passing through different resistance is different. But P.D. are same through each resistance.



Current through 2ohm resistor is

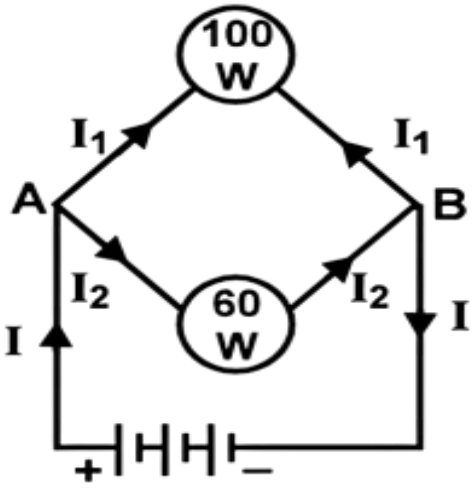
$$I = \frac{V}{R} = \frac{4\ V}{2\ ohm} = 2A$$

$$P = VI = 4V \times 2A = 8W$$

Q15. Two lamps, one rated 100W at 220V, and the other 60W at 220V, are connected in parallel to electric mains supply. What current is drawn from this if the supply voltage is 220V ?

Sol. Let the current drawn from the supply line = I

Let current passing through 100W and 60W lamps be I_1 and I_2 respectively.



Here, $I = I_1 + I_2$

Current passing through 100W is given by

$$I_1 = \frac{100}{220} = \frac{5}{11}\ A$$

Current passing through 60W is given by

$$I_2 = \frac{60}{220} = \frac{3}{11}\ A$$

Supply Current, $I = I_1 + I_2$

$$I = \frac{5}{11} + \frac{3}{11} A = \frac{8}{11}\ A = 0.727A$$

Q16. Which uses more energy, a 250W TV set in 1hr, or a 1200W toaster in 10minutes ?

Sol. Energy consumed by TV is given by

$$(E) = P \times t = \frac{2500}{1000} \times \frac{10}{60}\ kWh$$

$$= \frac{1}{64}\ kWh = 0.015\ kWh$$

Energy consumed by Toaster is given by

$$(E) = P \times t = \frac{1200}{1000} \times \frac{10}{60}\ kWh$$

$$= \frac{12}{64}\ kWh = 0.2\ kWh$$

Ans : Toaster uses more energy.

Q17. An electric heater of resistance 8ohm draws 15A from the service main in 2 hours. Calculate the rate at which heat is developed in the heater.

Sol. R = 8ohm ; Current, I = 15A ; t = 2h ;

We know that $H = VIt$

Rate at which heat is developed

$$= \frac{H}{t} = \frac{VIt}{t} = VI = I^2R$$

$$= 15 \times 15 \times 8 = 1800\,W = 1800\,J/s$$

Q18. Explain the following:

(a) Why is the tungsten used without exclusively for filament of electric lamps?

(b) Why are the conductors of electric irons, made of an alloy rather than a pure metal?

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

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

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

Sol.

(a) Tungsten is used almost exclusively for filament of incandescent lamps because of the following reasons

- It has very high resistivity
- It has very high melting point (3380°C)
- It does not oxidised easily.

(b) The conductors of electric devices such as bread toasters and electric irons are made of an alloy rather than a pure metal because of the following reasons.

- It has high resistivity.
- It has high melting point.
- It does not oxidised easily.

(c) The series arrangement is not found satisfactory for domestic circuits because if one appliance is switched off or gets fused all other appliances will also stop working because their electric supply will be cut off.

(d) We know that the resistance of a given wire is inversely proportional to its cross sectional area if the cross-sectional area of a conductor of a given material of a fixed length is increased, the resistance is lowered.

(e) Copper and aluminium wires are usually employed for electricity transmission because they are good conductors of electricity.