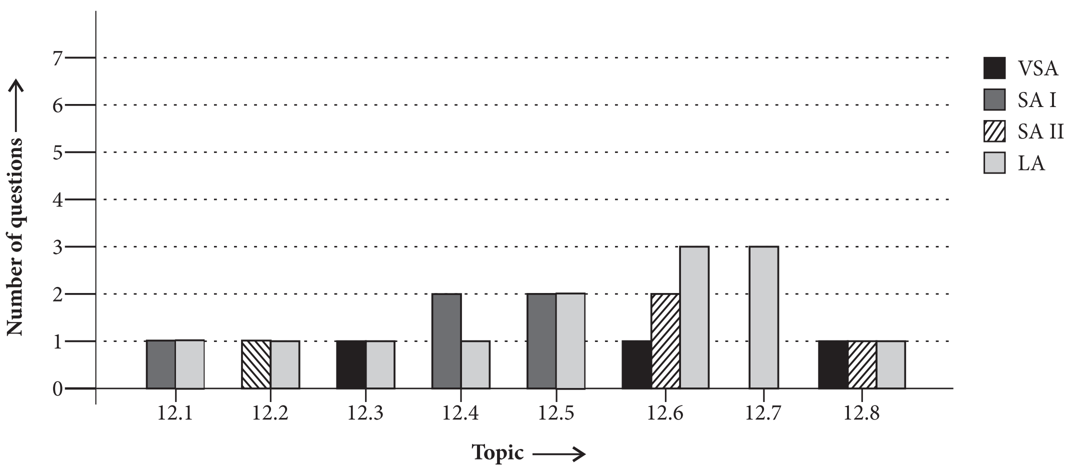
Chapter

12

Electricity

Topicwise Analysis of 2010-2008 Years' CBSE Board Questions



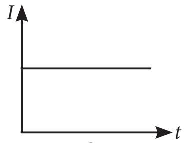
- Maximum weightage is of *Resistance of System of Resistors.*
- Maximum SA II type questions were asked from *Resistance of System of Resistors.*

QUICK RECAP

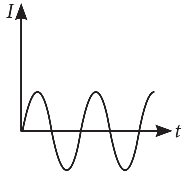
- **Charge :** Electrons have a negative charge of 1.6×10^{-19} C, while protons have an equal positive charge of 1.6×10^{-19} C.
- **Electric current :** The quantity of electric charge flowing through a conductor in one second.

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

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



Direct Current



Alternating Current

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

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

- SI unit of electric potential

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

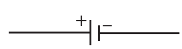
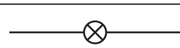
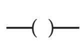
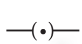
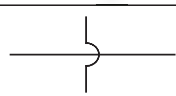
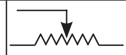
- **Electric potential difference :** The amount of work done in bringing unit positive charge from one point to another point in an electric field.

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

- It has the same SI unit as electric potential.

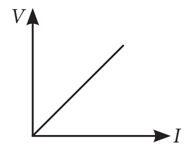
- **Electric potential energy :** The work required to be done to bring the charges to their respective location against the electric field with the help of a source of energy.
- This work done gets stored in the form of potential energy of charges.

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

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

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

- **Graphical representation :**



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

- The opposition caused to the flow of current is called resistance.
- The SI unit of resistance is ohm.

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

- **Factors affecting resistance :**
- **Length of the conductor :** The resistance of a conductor is directly proportional to the length of the conductor.
  $R \propto l$
- **Area of cross-section of the conductor :** The resistance of a conductor is inversely proportional to the area of the conductor.
  $R \propto 1/A$
- **Material of the conductor :** Two resistance made up of the same length and same area of cross-section but of different materials have different resistances.

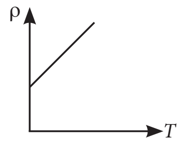
$$R \propto \frac{l}{A} \,;\, R = \rho\frac{l}{A} \text{ or } \rho = \frac{RA}{l}$$

- Resistivity, $\rho = \frac{\text{ohm m}^2}{\text{m}} = \text{ohm m } (\Omega \text{ m})$
- **Temperature :** With rise in temperature, the resistance of metals increases and decreases

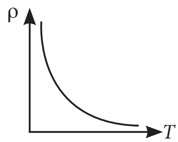
with decrease in temperature. Certain alloy like nichrome, manganin whose resistance vary negligible with temperature.

Effect of temperature on resistivity :

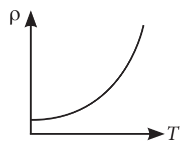
- Resistivity of a conductor increases linearly with increasing temperature.



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

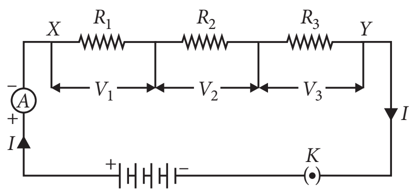


- Resistivity increases with rise in temperature in insulators.

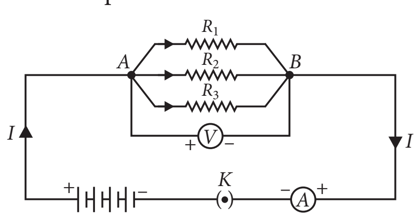


Combination of resistances :

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



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



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

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

  – The equivalent resistance is given by,

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

Heating effect of electric current :

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

Electrical power :

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

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

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

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

Electrical energy :

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

Electrical fuse :

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

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

Previous Years' CBSE Board Questions

12.1 Electric Current and Circuit

SA I (2 marks)

1. What is an electric circuit? Distinguish between an open and a closed circuit. *(AI 2009)*

LA (5 marks)

2. Name an instrument that measures electric current in a circuit, define the unit of electric current. *(1/5, Delhi 2008)*

12.2 Electric Potential and Potential Difference

SA II (3 marks)

3. (a) Define the term "volt".

(b) State the relation between work, charge and potential difference for an electric circuit.

Calculate the potential difference between the two terminals of a battery if 100 joules of work is required to transfer 20 coulombs of charge from one terminal of the battery to the other. *(AI 2009)*

LA (5 marks)

4. What is meant by saying that the potential difference between two points is 1 volt? Name a device that helps to measure the potential difference across a conductor? *(2/5, Delhi 2008)*

12.3 Circuit Diagram

VSA (1 mark)

5. Draw a schematic diagram of an electric circuit consisting of a battery of two cells each of 1.5 V, 5 Ω, 10 Ω and 15 Ω resistors and a plug key, all connected in series. *(AI 2009)*

LA (5 marks)

6. What do the following symbols mean in circuit diagrams?

(i) 

(ii)  *(1/5, Delhi 2008)*

12.4 Ohm's Law

SA I (2 marks)

7. Calculate the resistance of an electric bulb which allows a 10 A current when connected to a 220 V power source. *(AI 2009)*

8. (a) What is the shape of the graph obtained by plotting potential difference applied across a conductor against the current flowing through it?

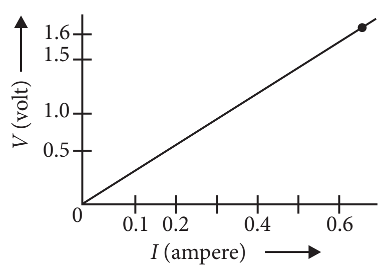
(b) What does the slope of this *V-I* graph at any point represent? *(Foreign 2009)*

LA (5 marks)

9. An electric circuit consisting of a 0.5 m long nichrome wire *XY*, and an ammeter, a voltmeter, four cells of 1.5 V each and a plug key was set up.

(i) Draw a diagram of this electric circuit to study the relation between the potential difference maintained between the points '*X*' and '*Y*' and the electric current flowing through *XY*,

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



What would be the values of $\frac{V}{I}$ 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? *(3/5, Delhi 2008)*

12.5 Factors on which the Resistance of a Conductor Depends

SA I (2 marks)

10. The electrical resistivity of silver is $1.60 \times 10^{-6}\ \Omega$ m. What will be the resistance of a silver wire of length 10 m and cross-sectional area $2 \times 10^{-3}\ m^2$? *(Foreign 2010)*

11. 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. *(Delhi 2009)*

LA (5 marks)

12. List the factors on which the resistance of a conductor depends. *(2/5, Foreign 2009)*

13. Electrical resistivities of some substances at 20°C are given below:

Silver	$1.60 \times 10^{-8}\ \Omega$ m
Copper	$1.62 \times 10^{-8}\ \Omega$ m
Tungsten	$5.20 \times 10^{-8}\ \Omega$ m
Iron	$10.0 \times 10^{-8}\ \Omega$ m
Mercury	$94.0 \times 10^{-8}\ \Omega$ m
Nichrome	$100 \times 10^{-8}\ \Omega$ m

Answer the following questions in relation to them :

(i) Among silver and copper, which one is a better conductor? Why?

(ii) Which material would you advise to be used in electrical heating devices? Why?

(3/5, Delhi 2008)

12.6 Resistance of System of Resistors

VSA (1 mark)

14. Why is a series arrangement not used for connecting domestic electrical appliances in a circuit? *(AI 2008)*

SA II (3 marks)

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

(i) minimum current flowing

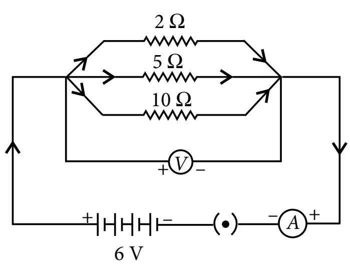
(ii) maximum current flowing

(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.

(Delhi 2009)

16. In the circuit diagram given below.



Calculate :

(a) the current through each resistor

(b) the total current in the circuit

(c) the total effective resistance of the circuit.

(Delhi 2008)

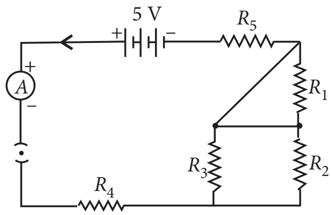
LA (5 marks)

17. Explain with the help of a labelled circuit diagram how you will find the resistance of a combination of three resistors of resistances R_1, R_2 and R_3, joined in parallel. Also mention how you will connect the ammeter and the voltmeter in the circuit when measuring the current in the circuit and the potential difference across one of the three resistors of the combination.

(Delhi 2010)

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

Consider the following electric circuit.



(i) Which two resistors are connected in series?

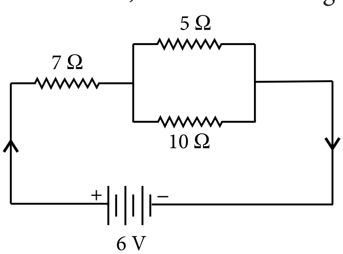
(ii) Which two resistors are connected in parallel?

(iii) If every resistor of the circuit is 2 Ω, what current will flow in the circuit?

(Foreign 2010)

19. (a) Two resistors R_1 and R_2 may form (i) a series combination or (ii) a parallel combination, and the combination may be connected to a battery of six volts. In which combination will the potential difference across R_1 and across R_2 be the same and in which combination will the current through R_1 and through R_2 be the same?

(b) For the circuit, shown in this diagram,



Calculate

(i) the resultant resistance

(ii) the total current

(iii) the voltage across 7 Ω resistor

(Foreign 2009)

12.7 Heating Effect of Electric Current

LA (5 marks)

20. Derive the expression for the heat produced due to a current '*I*' flowing for a time interval '*t*' through a resistor '*R*' having a potential difference '*V*' across its ends. With which name is the relation known? How much heat will an instrument of 12 W produce in one minute if it is connected to a battery of 12 V?

(Delhi 2010)

21. Derive an expression for the heat produced in a conductor of resistance *R* when a current *I* flows through it for time *t*.
Two identical resistors of resistance *R* are connected in series with a battery of potential difference *V* for time *t*. The resistors are then connected in parallel with the same battery for the same time *t*. Compare the heat produced in the two cases. *(Foreign 2010)*

22. Why does the connecting cord of an electric heater not glow red hot while the heating element does? *(1/5, Delhi 2008)*

12.8 Electric Power

VSA (1 mark)

23. Out of 60 W and 40 W lamps, which one has a higher electrical resistance when in use?

(AI 2008)

SA II (3 marks)

24. Two lamps, one rated 60 W at 220 V and the other 40 W at 220 V, are connected in parallel to the electric supply at 220 V.

(a) Draw a circuit diagram to show the connections.

(b) Calculate the current drawn from the electric supply.

(c) Calculate the total energy consumed by the two lamps together when they operate for one hour. *(AI 2008)*

LA (5 marks)

25. A 4 kW heater is connected to a 220 V source of power. Calculate

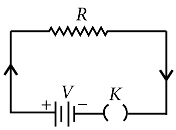
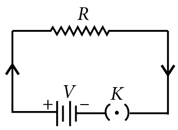
(i) the electric current passing through the heater.

(ii) the resistance of the heater.

(iii) the electric energy consumed in a 2 hours use of the heater. *(3/5, Foreign 2009)*

Detailed Solutions

1. Electric circuit : Closed and continuous path of an electric current is called an electric circuit.

	Open circuit	Closed circuit
1.	It is a discontinuous path of an electric current.	It is a continuous path of an electric circuit.
2.	Electric charge cannot flow.	Electric charge can flow.
3.	Key is open.	Key is closed.
	 open circuit	 closed circuit

2. Ammeter is an instrument that measures electric current in the circuit.
One ampere is defined as the flow of one coulomb of charge per second. *i.e.*, 1 A = 1 C s^{-1}.

3. (a) 'Volt' is the SI unit of electric potential difference, it is defined as the amount of work done in moving a unit positive charge from one point to another.
(b) The relationship between work (W), charge (Q) and potential difference (V) for an electric circuit is given by

$$V = \frac{W}{Q}$$

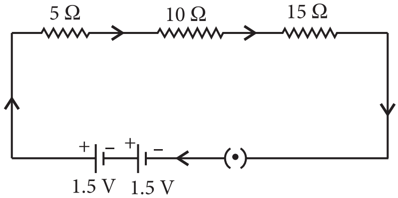
Given : $W = 100$ J, $Q = 20$ C, $V = ?$

Using the relation, $V = \frac{W}{Q} = \frac{100}{20} = 5$ V

So, 5 V of potential difference between the two terminals to transfer 20 C of charge when work done is 100 J.

4. When we say that the potential difference between two points is 1 V, it means that 1 J of work is being done to move a unit charge between that two points.
Voltmeter is a device that helps to measure the potential difference.

5. The required circuit diagram is as below :



6. (i) 

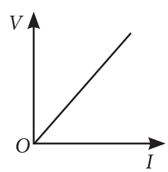
rheostat/variable resistance
(ii)  a closed key

7. Let V be the potential difference created by power sources. I be the current in the circuit and R be the resistance of the bulb.
Given, $V = 220$ V, $I = 10$ A
Using Ohm's law, $V = IR$

or $R = \frac{V}{I}$ or $R = \frac{220}{10}\Omega$

$R = 22\ \Omega$
Resistance of given electric bulb comes out to be 22 Ω.

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

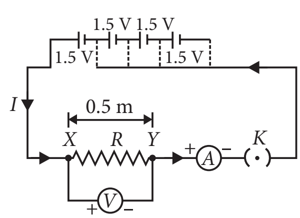


(b) According to ohm's law,

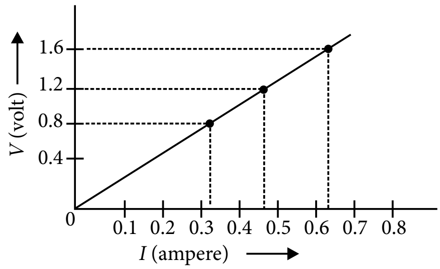
$V = IR$ or $I = \frac{V}{R}$

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

9. (i) Electric circuit to study the relation between potential difference and the current.



(ii)



The values of $\frac{V}{I}$ ratios when the potential differences across nichrome wire are 0.8 V, 1.2 V and 1.6 V, are

For $V = 0.8$ V, $I = 0.32$ A

$$\frac{V}{I} = \frac{0.8}{0.32} = 2.5$$

For $V = 1.2$ V, $I = 0.48$ A

$$\frac{V}{I} = \frac{1.2}{0.48} = 2.5$$

For $V = 1.6$ V, $I = 0.64$ A

$$\frac{V}{I} = \frac{1.6}{0.64} = 2.5$$

The values of $\frac{V}{I}$ ratios are 2.5, 2.5, 2.5, that means the ratio of potential difference applied to the wire and current passing through it is a constant.

10. Given, electrical resistivity of silver,
$\rho = 1.6 \times 10^{-6}\ \Omega$ m
Length of silver wire, $l = 10$ m
Area of cross-section, $A = 2 \times 10^{-3}$ m^2
As we know,
resistance of wire is given by

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

Putting the values of l, ρ and A, we get

$$R = 1.6 \times 10^{-6} \times \frac{10}{2 \times 10^{-3}} = 8.0 \times 10^{-3}\ \Omega$$

11. As we know that if R, ρ, l and A are respectively the resistance, resistivity, length and cross-sectional area of a given wire, then

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

Given : $R = 20\ \Omega$
If l is increased to $2l$, then $l' = 2l$

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

So, $R' = \rho \frac{2l}{A} = 2\left(\rho \frac{l}{A}\right)$

$R' = 2R$

$\therefore\ R' = 2 \times 20\ \Omega = 40\ \Omega$

So, the resistance of wire in the new situation is 40 Ω.

12. Resistance of a conductor depends upon the following factors:

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

$$R \propto l$$

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

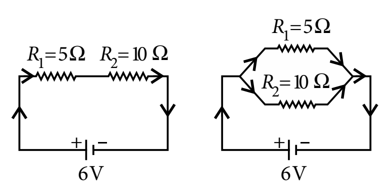
$$R \propto \frac{1}{A}$$

(iii) Nature of conductor.

13. (i) Silver is the best conductor of electricity because of low resistivity.
(ii) Nichrome should be used in electrical heating devices, due to very high resistivity. It has a high resistance and produces a lot of heat on passing current.

14. (1) In series arrangement, same current will flow through all the appliances, which is not required for domestic electric circuit.
(2) Total resistance of domestic circuit will be sum of the resistance of all appliances and hence current drawn by the circuit will be less.
(3) We cannot use independent on/off switches with individual appliances.
(4) All appliances are to be used simultaneously even if we do not need them.

15. (a) In order to make the flow of minimum current in the circuit, we can connect 5 Ω and 10 Ω resistors in series.
And to get maximum flow of current in the circuit, we can connect 5 Ω and 10 Ω resistors in parallel.



series combination parallel combination

(b) For series connection

Total resistance, $R = R_1 + R_2 = 5 + 10 = 15\ \Omega$

Using Ohm's law, $V = IR$

$$\therefore\ I = \frac{V}{R} = \frac{6}{15} A\ (\because\ V = 6\text{ V})$$

$$= 0.4\text{ A}$$

So, total current is 0.4 A.

For parallel connection

$$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} = \frac{1}{5} + \frac{1}{10} = \frac{3}{10}$$

$$\therefore\ R = \frac{10}{3}\ \Omega$$

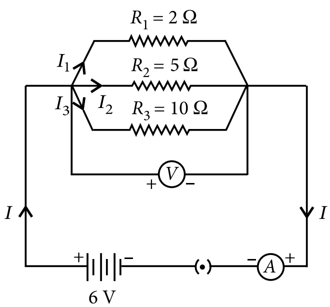
Total current in the circuit,

$$I = \frac{V}{R} \quad \text{(using Ohm's law)}$$

$$= \frac{6}{10/3} = \frac{6 \times 3}{10} = 1.8\text{ A}$$

So, total current in the circuit is 1.8 A.

16.



Let R_1, R_2 and R_3 be the three resistances with resistance value 2 Ω, 5 Ω and 10 Ω respectively.

(a) Let V_1, V_2 and V_3 be the potential differences across the resistors R_1, R_2 and R_3.

Let currents I_1, I_2, I_3 flow through the resistors R_1, R_2, R_3 respectively.

Since R_1, R_2 and R_3 are connected in parallel,

$$V_1 = V_2 = V_3 = 6\text{ V}$$

Now, current through R_1 is

$$I_1 = \frac{V_1}{R_1} \quad \text{(Using Ohm's law)}$$

$$= \frac{6}{2} = 3\text{ A}$$

Current through R_2 is $I_2 = \frac{V_2}{R_2} = \frac{6}{5} = 1.2\text{ A}$

Similarly, current through R_3, $I_3 = \frac{V_3}{R_3} = \frac{6}{10} = 0.6\text{ A}$

(b) Total current in circuit is given by

$$I = I_1 + I_2 + I_3 = 3 + 1.2 + 0.6 = 4.8\text{ A}$$

(c) Total effective resistance (R_p) of the circuit is given as

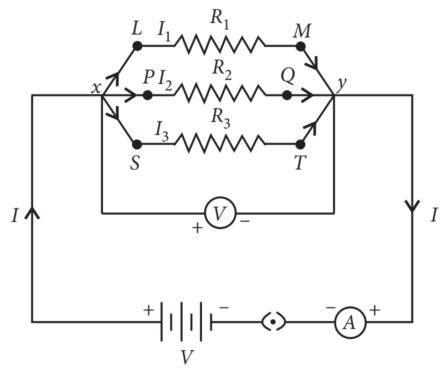
$$\frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

(as R_1, R_2 and R_3 are connected in parallel)

$$\frac{1}{R_p} = \frac{1}{2} + \frac{1}{5} + \frac{1}{10} = \frac{5+2+1}{10} = \frac{8}{10}$$

So, $R_p = \frac{10}{8}\ \Omega = 1.25\ \Omega$

17. The following circuit diagram depicts the parallel connection of three resistors R_1, R_2 and R_3.



The value of resistances are R_1, R_2 and R_3.

Let currents I_1, I_2 and I_3 flow through the resistors R_1, R_2 and R_3 respectively.

It is observed that total current I is equal to the sum of the separate currents through each branch. So,

$$I = I_1 + I_2 + I_3 \quad \text{...(i)}$$

Let R_P be the equivalent resistance. Then,

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

On applying Ohm's law to each resistor,

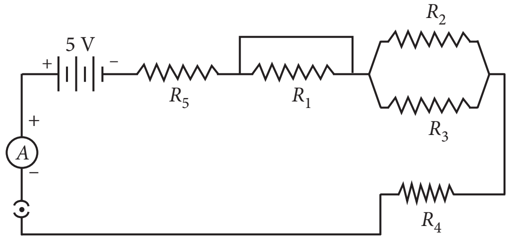
$$I_1 = \frac{V}{R_1},\ I_2 = \frac{V}{R_2},\ I_3 = \frac{V}{R_3}$$

From equation (i), we have

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

18. *Refer to answer 17.*

Given circuit can be redrawn as follows :



(i) Resistors, R_5 and R_4 are connected in series.

(ii) Resistors, R_2 and R_3 are connected in parallel.

(iii) Equivalent resistance of R_2 and R_3 will be

$$\frac{1}{R'} = \frac{1}{R_2} + \frac{1}{R_3} = \frac{1}{2} + \frac{1}{2}$$

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

Then R' is connected in series with R_4 and R_5.

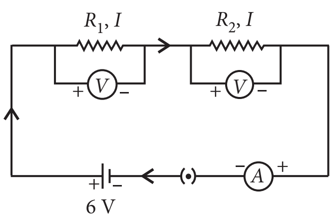
So, equivalent resistance of the circuit is

$R_{eq} = R' + R_4 + R_5 = 1 + 2 + 2 = 5\ \Omega$

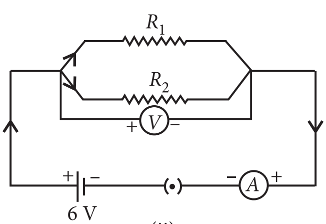
Using Ohm's law, $I = \frac{V}{R_{eq}} = \frac{5}{5} = 1\text{ A}$

So, total current flowing in the circuit will be 1 A.

19. (a)



(i)

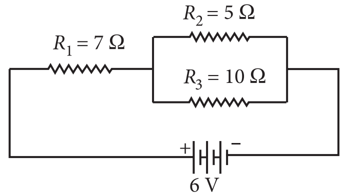


(ii)

In series combination, current remains same in all resistors and in parallel combination, voltage potential difference remains constant.

So, in circuit (ii), the potential difference will be the same across R_1 and R_2. In circuit (i) the current will be the same across R_1 and R_2.

(b)



(i) In the above circuit, R_2 and R_3 are connected in parallel and the combination of R_2 and R_3 are connected in series with R_1.

For equivalent resistance of R_2 and R_3,

$$\frac{1}{R'} = \frac{1}{5} + \frac{1}{10} = \frac{2+1}{10}$$

$$R' = \frac{10}{3}\ \Omega$$

Then R' is connected in series with R_1. So, equivalent resistance of the given circuit is :

$$R_{eq} = R' + R_1 = \frac{10}{3} + 7 = \frac{31}{3}\ \Omega$$

(ii) Total current can be calculated as follows:

$$I = \frac{V}{R_{eq}} = \frac{6}{31/3}\text{ A} = \frac{18}{31}\text{ A}$$

$I = 0.58$ A

(iii) Voltage across $R_1 = 7\ \Omega$ resistor is

$V_1 = I \times R_1 = 0.58 \times 7 = 4.06$ V

20. (a) As we know, from the definition of potential difference (V),

$$V = \frac{W}{Q}, \quad \text{...(i)}$$

here, 'W' is work done in moving charge from one point to another, 'Q' is the amount of charge.

$W = V \times Q$

$$W = V \times \frac{Q}{t} \times t$$

(On multiplying and dividing by time 't')

$\therefore \quad W = VIt$

Since this work done is converted into heat energy, so, we can write

$H = VIt$ ...(ii)

Where 'H' is heat energy produced by electrons.

From Ohm's Law,

$V = IR$, here, R is the resistance of the resistor.

Putting this in equation (ii), we get

$H = I^2Rt$

Above relation is also known as Joule's law of heating.

(b) Since, heat developed = power × time

$\therefore \quad H = P \times t$

Given, P = 12 W; t = 1 min = 60 s

So, heat developed in 1 min = 12 × 60 = 720 J

21. *Refer to answer 20 (a).*

If resistors are connected in series

Total resistance of the combination would be,

$R_S = R + R = 2R$

Let H_s be the heat produced in series combination.

$\therefore \quad H_S = I^2{}_S R_S t$

or $H_S = \dfrac{V^2}{R_S} t$

$$H_S = \frac{V^2}{2R} t = \frac{1}{2}\left(\frac{V^2}{R} t\right)$$

If resistors are connected in parallel

Total resistance (R_P) can be

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

$$\therefore \quad R_P = \frac{R}{2}$$

Let H_P be the heat produced in parallel combination,

$$H_P = \frac{V^2}{R_P} t = \frac{V^2}{\frac{R}{2}} \times t = 2\frac{V^2}{R} t$$

So, $H_P = 4H_S$

So, heat produced in parallel combination will be four times the heat produced in series.

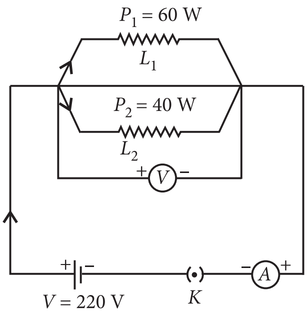
22. Connecting cord has very low resistance than heating element. Since heat produced in a material due to electric current is directly proportional to its resistance. Hence, heating element will glow red hot and connecting cord does not.

23. We know that : $P = \dfrac{V^2}{R}$

Power is inversely proportional to the resistance.

$\therefore$ 40 W has a higher electrical resistance.

24. (a) The circuit diagram for the given connection can be drawn as follows:



where L_1 and L_2 are the two lamps, P_1 and P_2 are their corresponding powers.

(b) Since L_1 and L_2 are connected in parallel, so they will get same voltage, V = 220 V.

We know that, power generated in appliance is given by

$P = VI$, where I is current.

So, $I = \dfrac{P}{V}$

For lamp L_1,

Current, $I_1 = \dfrac{P_1}{V} = \dfrac{60}{220}$ A $= \dfrac{3}{11}$ A

For lamp L_2,

Current, $I_2 = \dfrac{P_2}{V} = \dfrac{40}{220}$ A $= \dfrac{2}{11}$ A

So, total current drawn from the electric supply will be

$$I = I_1 + I_2 = \frac{3}{11} + \frac{2}{11} = \frac{5}{11} \text{ A}$$

(c) Since total power of the circuit will be

$$P = VI = 220 \times \frac{5}{11} \text{ W} = 100 \text{ W} = 0.1 \text{ kW}$$

Energy consumed in one hour will be

$E = P \times t$ (where t is time)

= 0.1 × 1 kWh = 0.1 kWh = 0.1 unit

25. Power of the heater, P = 4 kW = 4000 W

Voltage of source of power, V = 220 V

(i) Since, $P = VI$ (I is the current)

or $I = \dfrac{P}{V} = \dfrac{4000}{220} = 18.18$ A

(ii) Power, P is also given by

$P = I^2R$

$$R = \frac{P}{I^2} = \frac{4000}{(18.18)^2} = 12\ \Omega$$

(iii) Since, electric energy consumed is given by

$E = P \times t$ (where t is time)

E = 4 kW × 2h = 8 kWh

E = 8 unit