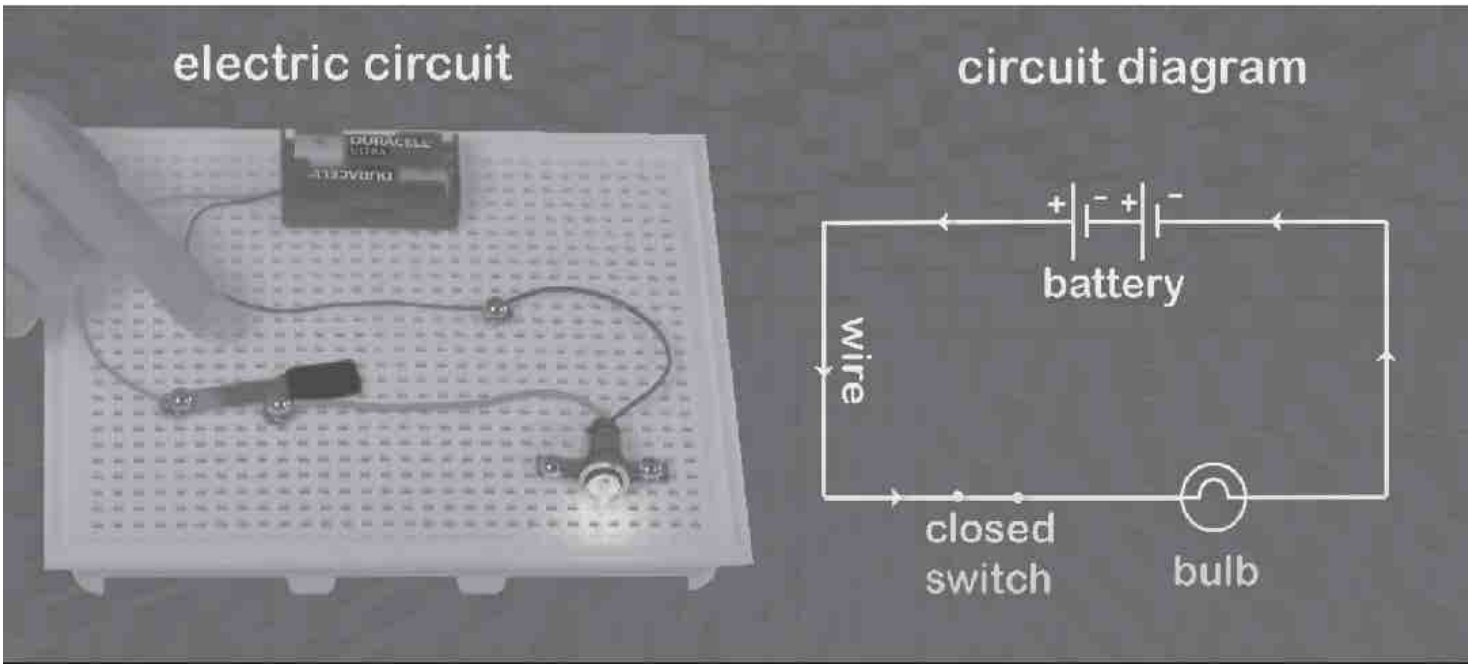
12 Electricity



The most basic concept of an electrical circuit is shown above, which is the basis of this chapter. Here a duracell battery is used to light up a bulb using just wires and a switch. Fascinating concept that runs all our digital devices daily!

Topic Notes

- *Electric Current and Circuit*
- *Electric Potential and Potential Difference*
- *Circuit Diagram*
- *Ohm's Law*
- *Factors on which Resistance of a Conductor depends*
- *Resistance of a System of Resistors*
- *Heating Effect of Electric Current*
- *Electric Power*

TOPIC 1

ELECTRIC CURRENT AND CIRCUIT

Electricity is a form of energy and can be readily transmitted over large distances with relatively small loss in energy. In this chapter we will discuss about electric circuits, potential difference and flow of current in an electric circuit. We will also discuss Ohm's law and the heating effect of electric current and its applications.

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

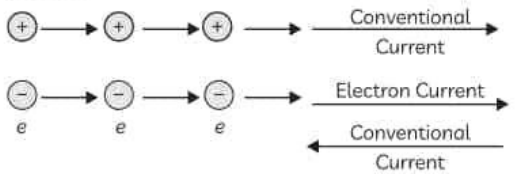
Electric Current

Electric current is expressed by the amount of charge flowing through a particular of area in unit time. It is defined as the rate of flow electric charges i.e., the charge flowing per unit time.

Let Q denote the amount of charge flowing across a given point in the conductor in time t, then the current flowing is given by, $I = Q/t$.

Conventional Direction of Current flow

It is the direction in which the positive charges flow which is opposite to the direction of flow of negative charges.



Ampere: One Ampere is defined as the current flowing when 1 Coulomb of charge flows across a point in 1 second.

$$1 \text{ Ampere} = \frac{1 \text{ Coulomb}}{1 \text{ second}}$$

Small quantities of current are expressed in milliampere ($1 \text{ mA} = 10^{-3}$ A) or in microampere ($1 \mu A = 10^{-6}$ A).

Coulomb: It is the SI unit of charge and is the charge carried by 6×10^{18} electrons, since the charge of 1 electron = 1.6×10^{-19} C.

Example 1. Calculate the number of electrons constituting one coulomb of charge. [NCERT]

Ans. The charge on one electron (e) = 1.6×10^{-19} C.

Also, Charge $q = ne$, where n is the number of electrons. Therefore,

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

Ammeter: It is an instrument to measure electric current in a circuit and is always connected in series in a circuit through which the current is to be measured. The electric current flows in the circuit shown from the positive terminal to the negative terminal of the cell through the bulb and the ammeter.

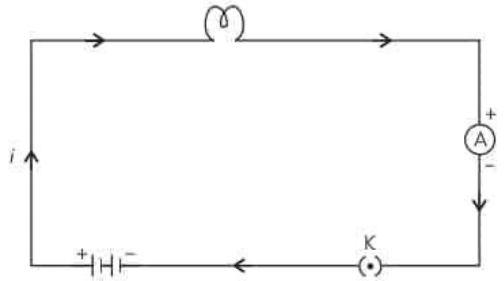


Figure above shows the schematic diagram of a typical electric circuit comprising a cell, an electric bulb, an ammeter and a plug key. The electric current flows in the circuit from the positive terminal of the cell to the negative terminal of the cell through the bulb and ammeter.

Flow of charge inside a conductor: When a wire is connected to a battery, the electrons which were drifting randomly in all directions, now become aligned in a particular direction and current begins to flow across the wire. When a steady current flows through a conductor, the electrons in it move with a certain average drift velocity.

TOPIC 2

ELECTRIC POTENTIAL AND POTENTIAL DIFFERENCE

Electric Potential

Electric potential at a point is defined as the work done in moving a unit positive charge from infinity to that point.

Potential Difference

Potential Difference between two points on a conductor carrying current is defined as the work defined in moving a unit positive charge from one point to the other.

$$\text{Potential Difference} = \frac{\text{Work Done (W)}}{\text{Charge (Q)}}$$

Example 2. How much energy is given to each coulomb of charge passing through a 6 V battery? [NCERT]

Ans. It is given that charge q = 1 C, V = 6V.

We know that work done $W = qV = 1 \times 6\ J = 6\ J$.

Therefore, 6J energy is given to one coulomb of charge passing through 6 V battery.

tween two points in a current carrying conductor when 1 Joule of work is done in moving a charge of 1 Coulomb from one point to another.

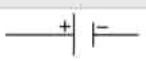
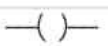
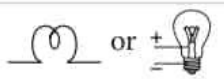
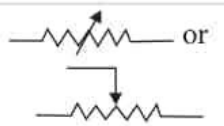
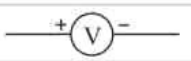
$$1\ \text{Volt} = \frac{1\ \text{Joule}}{1\ \text{Coulomb}}$$

Voltmeter: It is an instrument to measure the potential difference. The voltmeter is always connected in parallel across the points between which the potential difference is to be measured.

TOPIC 3

CIRCUIT DIAGRAM

A circuit diagram is a schematics diagram of an electric circuit in which different components of the circuit are represented by conventionally used symbols.

S. No.	Components	Sumbols
(1)	An electric cell	
(2)	A battery or a combination of cells	
(3)	Plug key or switch (open)	
(4)	Plug key or switch (closed)	
(5)	A wire joint	
(6)	Wires crossing wi-thot joining	
(7)	Electric bulb	
(8)	A resistor of resistance R	
(9)	Variable resistance or rheostat	
(10)	Ammeter	
(11)	Voltmeter	

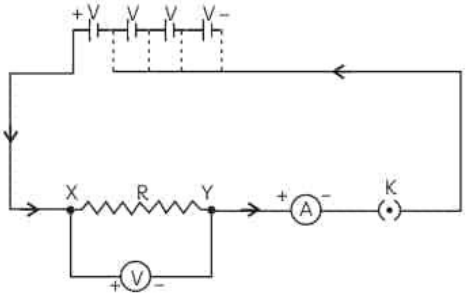
TOPIC 4

OHM'S LAW

Let us find out if there is any relationship between the potential difference across a conductor And the current through it.

Example 3. Case Based:

Set up a circuit as shown in Fig. below, consisting of a nichrome wire XY of length, say 0.5 m, an ammeter, a voltmeter and four cells of 1.5 V each.



First use only one cell as the source in the circuit. Note the reading in the ammeter I, for the current and reading of the voltmeter V for the potential difference across the nichrome wire XY in the circuit. Tabulate them in the Table given.

S. No.	*Number of Cells Used in the Circuit*	*Current Through the Nichrome Wire, I (Ampere)*	*Potential Difference Across the Nichrome Wire, V (volt)*	*V/I (Volt/Ampere)*
(1)	*1*			
(2)	*2*			
(3)	*3*			
(4)	*4*			

respective readings of the ammeter and voltmeter for the values of current through the nichrome wire and potential difference across the nichrome wire. Repeat the above steps using three cells and then four cells in the circuit separately. **[NCERT Activity 12.1]**

(A) Nichrome is an alloy of:

(a) Nickel and Chromium

(b) Nickel, Chromium and Iron

(c) Nickel, Chromium, Manganese and Iron

(d) Nickel, Chromium, Magnesium and Iron

(B) Select the correct observations when the above activity is repeated with one cell, two cells, three and then four cells:

(I) On increasing the number of cells in the circuit, the reading of voltmeter increases.

(II) On increasing the number of cells in the circuit, the reading of voltmeter decreases.

(III) On increasing the number of cells in the circuit, the reading of ammeter increases.

(IV) On increasing the number of cells in the circuit, the reading of ammeter decreases.

(a) Both (I) and (III)

(b) Both (I) and (IV)

(c) Both (II) and (III)

(d) Both (II) and (IV)

(C) A student tabulated the voltmeter and ammeter readings as shown in the table below. What conclusions can be drawn regarding V/I ratio and the nature of the graph?

S. No.	Number of Cells used in the Circuit	Current Through the Nichrome wire, I (Ampere)	Potential Difference Across the Nichrome wire, V (volt)	V/I (Volt/Ampere)
(1)	1	0.1	1.5	15
(2)	2	0.2	3.0	15
(3)	3	0.3	4.5	15
(4)	4	0.4	6.0	15

(D) Will there be any change if the position of the voltmeter and ammeter are interchanged?

(E) Assertion (A) : The V/I ratio increases linearly with increase in potential difference.

Reason (R) : The V–Igraph is a straight line that passes through the origin of the graph.

(a) Both (A) and (R) are true and (R) is the correct explanation of the assertion.

(b) Both (A) and (R) are true, but (R) is not the correct explanation of the assertion.

(c) (A) is true, but (R) is false.

(d) (A) is false, but (R) is true.

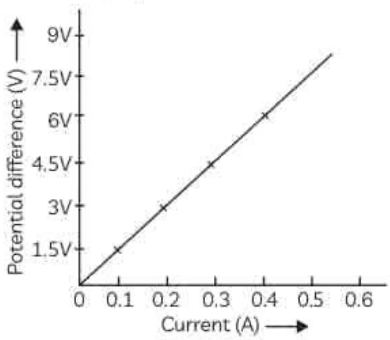
Ans. **(A)** *(c) Nickel, Chromium, Manganese and Iron*

Explanation: Nichrome is an alloy of Nickel, Chromium, Manganese and Iron commonly used in resistances and heating elements.

(B) *(a) Both (I) and (III)*

Explanation: On increasing the number of cells in the circuit, the reading of voltmeter increases as the potential difference across the nichrome wire increases. When potential difference across the nichrome wire increases, the current also increases.

(C) The V/I ratio is a constant for the given nichrome wire. The graph between V and I is a straight line passing through the origin as shown in the graph below:

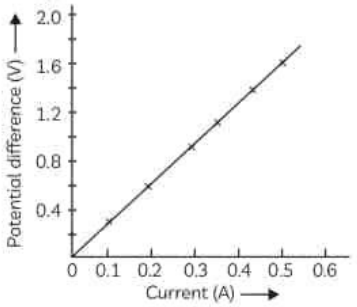


(D) Voltmeter is a device having high resistance for measuring the potential difference and is always connected in parallel across the component whose potential difference is to be measured. Ammeter is a device having low resistance for measuring the electric current flowing in the circuit. If the ammeter is connected in place of voltmeter, it will get burnt as all the current will flow through it since it has very low resistance. Moreover, connecting a high resistance voltmeter in the circuit will increase the overall resistance in the circuit and it will not show the correct values.

(E) *(d) (A) is false, but (R) is true.*

Explanation: The V-I graph is a straight line that passes through the origin which shows that the V/I ratio for a given nichrome wire is a constant value that does not change. The value of current I increases linearly when potential difference V is increased.

conditions remaining the same, the current passing through a wire is directly proportional to the potential difference across the wire. In other words, $V \propto I$ or, $V = IR$, where V is the potential difference across the wire, I is the current flowing and R is the constant of proportionality, known as the Resistance of the wire.



Resistance

It is a property of a wire which retards the flow of the current through the wire. It is due to the opposition encountered by the electrons as the electrons are restrained by the attractive force of the atoms and also due to the collisions with other electrons and with the atoms.

1 Ohm

It is the unit of resistance. The resistance of a conductor is said to be 1 Ohm when a potential difference of 1 Volt across the ends of the conductor produces a current of 1 ampere.

Rheostat

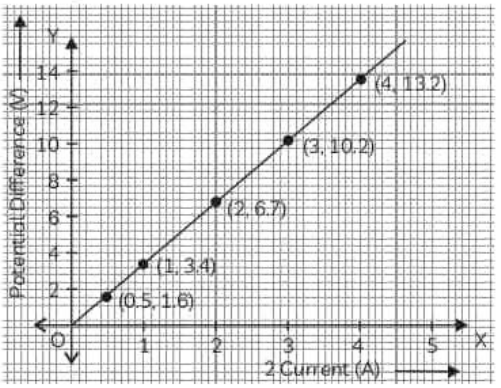
It is a device which is used in an electric circuit to change the resistance in the circuit.

Example 4. 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 (amperes)	0.5	1.0	2.0	3.0	4.0
V (volts)	1.6	3.4	6.7	10.2	13.2

resistance of that resistor. [NCERT]

Ans. The graph between V and I is drawn below:



The resistance of the resistor can be found from the graph by finding the slope of the VI graph.

R = slope of VI graph

$$= \frac{V_2 - V_1}{I_2 - I_1} = \frac{13.2 - 1.6}{4 - 0.5} = \frac{11.6}{3.5} = 3.31 \text{ Ohm}$$

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

Ans. It is given that V = 220 V and I = 5 A.

Therefore, required resistance $R = \frac{V}{I} = \frac{220}{5} = 44\Omega$.

Let the number of individual resistors connected in parallel be n. Then the effective resistance these n resistors = 44 Ω.

Effective resistance of resistances in parallel combination is given by resistors

$$\frac{1}{R_{eq}} = \frac{1}{44} = \frac{1}{R_1} + \frac{1}{R_2} + \ldots = \frac{n}{176}$$

$$\Rightarrow \quad n = \frac{176}{44} = 4 \text{ resistors}$$

TOPIC 5

FACTORS ON WHICH RESISTANCE OF A CONDUCTOR DEPENDS

Consider a wire of length L, area of cross section A and having a resistance R. Then the resistance of the wire directly proportional to the length of the wire and inversely proportional to the area of cross section of the wire. *i.e.*,

$$R \propto L \text{ and } R \propto 1/A, \text{ or}$$
$$R = \rho L/A$$

Example 6. Will current flow more easily through a thick wire or a thin wire of the same material, when connected to the same source? Why?

[NCERT]

Ans. Current will flow more easily through a thick wire as a thick wire has a greater area of cross section and hence less resistance. We know that resistance is directly proportional to the area of cross section and therefore resistance of a thick wire will be less which means that current will flow more easily as

Example 7. Let the resistance of an electrical component remains constant while the potential difference across the two ends of the component decreases to half of its former value. What change will occur in the current through it? [NCERT]

be equal to R and potential difference across its two ends be V. Therefore, according to Ohm's law, $V = IR$ or $I = \frac{V}{R}$.

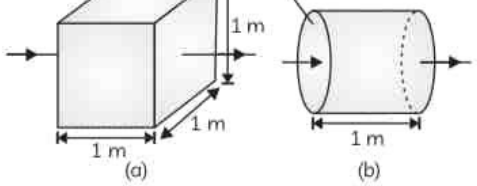
Now, if V becomes half or $\frac{V}{2}$, resistance remaining same,

then $I = \frac{V/2}{R} = \frac{V}{2R} = \frac{1}{2} \times \frac{V}{R} = \frac{1}{2} I$.

Therefore, current also becomes half.

Resistivity

It is an important property of materials and is defined as the resistance offered by a cube of a material of side 1 m when current flows perpendicular to the opposite faces.



It is measured in ohm-m. It is a characteristic property of the material and varies with temperature. Metals and alloys have very low resistivity but insulators have very high resistivity.

Applications of Alloys

Alloys are used in electric heating devices such as electric irons, geysers & toasters for the following reasons:

(1) The resistivity of alloys is generally higher than that of pure metals which form the alloy.

(2) They do not oxidize readily at high temperature since resistivity changes less rapidly with changes in temperature.

TOPIC 6

RESISTANCE OF A SYSTEM OF RESISTORS

There are two methods of joining the resistors together. Figure below shows an electric circuit in which three resistors having resistances R_1, R_2 and R_3, respectively, are joined end to end. Here the resistors are said to be connected in series.

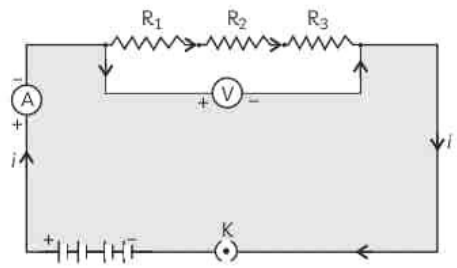
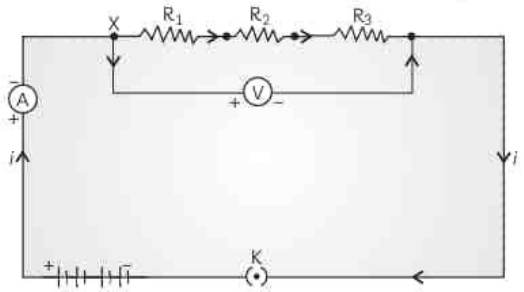


Figure below shows a combination of resistors in which three resistors are connected together between points X and Y. Here, the resistors are said to be connected in parallel.



Resistors in Series

If the resistors are connected in such a way that there is only one path through current flows, they are said to be connected in series. The potential difference V is equal to the sum of the potential differences V_1, V_2 and V_3. That is the total potential difference across a combination of resistors in series is equal to the sum of the potential difference across the individual resistors. That is,

$V = V_1 + V_2 + V_3$

The effective resistance in series combination is given by $R = R_1 + R_2 + R_3$

Resistors in Parallel

If the resistors are connected in such a way that the potential difference across each resistor is same, they are said to be connected in parallel.

Example 8. **Case Based:**

Make a parallel combination, XY, of three resistors having resistances R_1, R_2, and R_3, respectively. Connect it with a battery, a plug key and an ammeter, as shown in Fig-1 below.

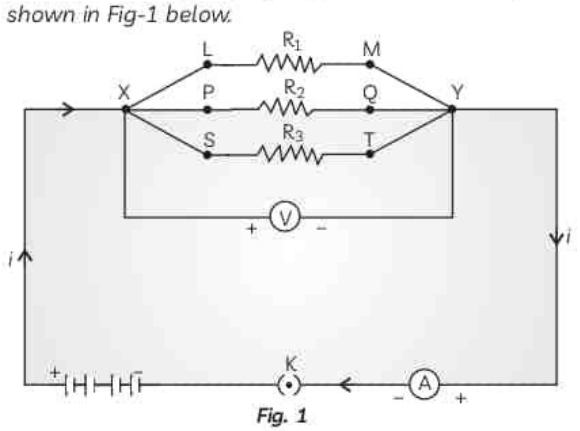


Fig. 1

combination of resistors.

Let us take resistances R_1, R_2, and R_3 of values 2 Ω, 4 Ω and 12 Ω respectively and let V = 6 V.Plug the key and note the ammeter reading. Let the current be I. Also take the voltmeter reading. It gives the potential difference V, across the combination. The potential difference across each resistor is also V.

Take out the plug from the key. Remove the ammeter and voltmeter from the circuit. Insert the ammeter in series with the resistor R_1, as shown in Fig. 2 below.

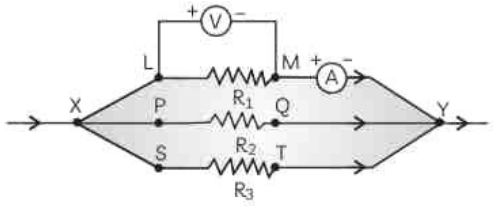


Fig. 2

Note the ammeter reading, I_1. Similarly, measure the currents through R_2 and R_3. Let these be I_2 and I_3, respectively.

(A) Refer to Fig. 1 in the given activity. A student recorded the readings of voltmeter and ammeter in a table as given below. Select the row containing correct observations.

	Reading of Voltmeter (V) (Volt)	Reading of Ammeter (I) (Amp)
(a)	6 V	7.2 A
(b)	6 V	5 A
(c)	3 V	10 A
(d)	3 V	1.5 A

(B) The reading of the ammeter when it is connected in series with the resistor R1 is:

(a) 0.5 A **(b) 1.5 A**

(c) 3 A **(d) 5 A**

(C) What is the relation between the total current and the currents flowing in each of the resistors?

(D) What is the relation between the current flowing in resistors R_2 and R_3 and their resistances?

(E) Assertion (A) : The ammeter readings will be different when connected through any of the resistors R_1, R_2 or R_3.

Reason (R) : The current flowing through any resistor can be found by using Ohm's law.

(a) Both (A) and (R) are true, and (R) is the correct explanation of the (A).

(b) Both (A) and (R) are true, but (R) is not the correct explanation of the (A).

(c) (A) is true, but (R) is false.

(d) (A) is false, but (R) is true.

Reading of Voltmeter (V): 6 V; Reading of Ammeter (I): 5 A

Ans. (A) *(b) Reading of Voltmeter: 6V; Reading of Ammeter: 5 A*

Explanation: The reading of voltmeter = 6 V and reading of ammeter = 5 A as the resistances are connected in parallel and the current across the resistors R_1, R_2 and R_3 will be 6/2 or 3 A, 6/4 or 1.5 A and 6/12 or 0.5 A respectively. Therefore, total current will be 5 A. Voltmeter reading will be the potential difference = 6 V.

(B) *(c) 3 A*

Explanation: When the ammeter is connected in series with the resistor R_1, it will show the current flowing I_1 through the resistor R_1 which can be found by using Ohm's law.

$$V = I_1R_1$$

$$\Rightarrow \quad I_1 = \frac{V}{R_1} = \frac{6}{2} = 3A$$

(C) The total current I is equal to the sum of the currents flowing in each of the resistors. If I is the total current and the current flowing in resistors R_1, R_2 and R_3 is given by I_1, I_2 and I_3 respectively, then $I = I_1 + I_2 + I_3$.

(D) The currents I_2 and I_3 flowing in resistors R_2 and R_3 respectively are calculated by using Ohm's law, keeping in mind that V is same for all resistors connected in parallel.

$$I_2 = \frac{V}{R_2} = \frac{6}{4}A = 1.5\ A$$

and

$$I_3 = \frac{V}{R_3} = \frac{6}{12}A = 0.5A$$

Ratio of $I_2 : I_3 = 1.5 : 0.5 = 3 : 1$ whereas ratio of $R_2 : R_3 = 4 : 12 = 1 : 3$.

Therefore, we can conclude that the currents I_2 and I_3 flowing in resistors R_2 and R_3 respectively are inversely proportional to the resistances.

(E) *(b) Both (A) and (R) are true, but (R) is not the correct explanation of the (A).*

Explanation: The ammeter readings will be different when connected through any of the resistors R_1, R_2 or R_3 as the potential difference across the resistors in parallel is same but current divides itself in the branches inversely as the resistance in that branch.

proportional to its resistance resulting in the smaller resistance having the larger current. Ohm's law is used to find the current flowing in each branch through any resistor.

The total current I is equal to the sum of the separate currents through each branch of the combination. $I = I_1 + I_2 + I_3$.

The effective resistance in parallel combi-nation is given by $\frac{1}{R}=\frac{1}{R_1}+\frac{1}{R_2}+\frac{1}{R_3}$

Example 9. An electric lamp of 100 Ω, a toaster of resistance 50 Ω, and a water filter of resistance 500 Ω are connected in parallel to a 220 V source. What is the resistance of an electric iron connected to the same source that takes as much current as all three appliances, and what is the current through it? [NCERT]

Ans. Let the resistance of electric lamp, toaster and water filter be denoted by R_1, R_2 and R_3 respectively.

Then, $R_1 = 100\ \Omega$, $r_2 = 50\ \Omega$ and $R_3 = 500\ \Omega$.

As the three appliances are connected in parallel, the resistance of an electric iron connected to the same source should be equal to the equivalent resistance of the three appliances in parallel (since current is same).

Equivalent resistance is given by

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

Therefore, $\frac{1}{R_{eq}}=\frac{1}{100}+\frac{1}{50}+\frac{1}{500}=\frac{5+10+1}{500}=$

$$\frac{16}{500}\Rightarrow R_{eq}=\frac{500}{16}=31.25\ \text{Ohm}.$$

Therefore, resistance of an electric iron connected to the same source that takes as much current as all three appliances = 31.25 Ohm.

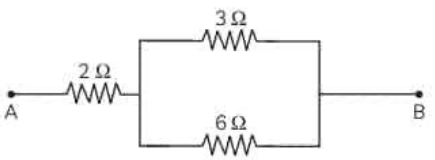
Current through the iron is calculated using Ohm's law, V = IR or $I=\frac{V}{R}=\frac{220}{31.25}=7.04A$

Comparison of Resistors in Series and Parallel

Resistors in Series	Resistors in Parallel
The resistance of the combination of resistors is equal to the sum of the individual resistors.	The sum of the reciprocals of the individual resistances is equal to the reciprocal of equivalent resistance, R.
The total voltage across the combination is equal to the sum of the voltage drop across the individual resistors.	The voltage across each resistor is the same and is also equal to the voltage across the whole group.
The current is same in every part of the circuit	The currents in various resistors are inversely proportional to the resistances. The total current is the sum of the currents flowing in different branches.
$R = R_1 + R_2 + R_3$, where R_1, R_2 and R_3 are the resistances in series and R is the equivalent resistance.	$\frac{1}{R}=\frac{1}{R_1}+\frac{1}{R_2}+\frac{1}{R_3}$, where R_1, R_2 & R_3 are the resistances in series and R is the equivalent resistance.

Example 9. How can three resistors of resistances 2 Ω, 3 Ω, and 6 Ω be connected to give a total resistance of (a) 4 Ω, (b) 1 Ω? [NCERT]

Ans. (a) For getting a total resistance of 4 Ω, we should connect the resistors as shown below:

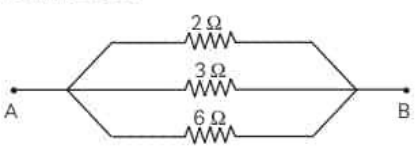


The equivalent resistance of parallel combination of 3 Ω and 6 Ω is given by

$$\frac{1}{R_{eq}}=\frac{1}{3}+\frac{1}{6}=\frac{2+1}{6}=\frac{3}{6}\Rightarrow R_{eq}=2\ \Omega.$$

When this combination is connected with a 2 Ω resistor, the total resistance = 2 + 2 = 4Ω.

(b) For getting a total resistance of 1 Ω, we should connect all the resistors in parallel as shown below:



The equivalent resistance of three resistors in parallel is given by $\frac{1}{R_{eq}}=\frac{1}{R_1}+\frac{1}{R_2}+\frac{1}{R_3}=\frac{1}{2}+\frac{1}{3}+\frac{1}{6}$

$$=\frac{3+2+1}{6}=\frac{6}{6}=1\Rightarrow R_{eq}=1\Omega.$$

HEATING EFFECT OF ELECTRIC CURRENT

Electric Energy

Work must be done continuously to maintain current in a conductor as the conductors offer resistance to the flow of current. The amount of work done W in carrying a charge Q through a wire of resistance R in time t is given by W = QV. Since Q = I X t, therefore, W = V X I X t, where V is the potential difference across the wire. Since by Ohm's law, V = IR, therefore, $W = I^2Rt$.

The electric energy dissipated or consumed is directly proportional to the square of the current I, directly proportional to the resistance R and to the time t during which current flows. $H = I^2Rt$.

Joule's Law of Heating

The relation $H = I^2Rt$ implies that heat produced in a resistor is directly proportional to the square of current for a given resistance and directly proportional to the resistance for a given current and directly proportional to the time for which the current flows through the resistor.

Example 11. 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** **[NCERT]**

Ans. *(c) 1:4*

Explanation: The resistances of the two conducting wires of same material and equal lengths and dimensions are equal. Let it be denoted by R. The heat produced in a resistor is given by $H = \frac{V^2}{R}t$.

When the two resistances are first connected in series, their effective resistance = 2R and when connected in parallel, their effective resistance = R/2.

When connected in series, the heat produced would be $H_s = \frac{V^2}{2R}t$ and when connected in parallel, the heat produced would be $H_p = \frac{V^2}{R/2}t = \frac{2V^2}{R}t$.

Therefore, ratio of heat produced in series and parallel combinations $= \frac{H_s}{H_p} = \frac{V^2t}{2R} \div \frac{2V^2t}{R} = 1:4$

Applications of Heating Effects of Current

The electric iron, toaster, oven, kettle, etc. are some of the electrical devices which are based on Joule's heating. The electric heating is also used to produce light. The fuse is another application of Joule's heating.

The Electric Bulb

The filament of the bulb must retain as much of the heat generated as is possible so that it gets hot and emits light. A metal having high melting point such as Tungsten should be used so that it does not melt at very high temperatures. The filament should be thermally isolated. The bulbs are filled with inert gases such as nitrogen and argon so as to prolong the life of filament.

Fuse

It protects circuits and appliances by stopping the flow of any unusually high electric current. The fuse is placed in series with the device. It consists of a piece of wire made of a metal or an alloy of appropriate melting point. If a current larger than the specified value flows through the circuit, the temperature of the fuse wire increases which melts the fuse wire and breaks the circuit.

Example 12. Why does the cord of an electric heater not glow while the heating element does? **[NCERT]**

Ans. Cord of an electric heater is made up of good conductor of electricity such as copper having low resistivity whereas the heating element is made up of a material having higher resistivity and hence higher resistance. Therefore, heat produced will be much more in heating element than the cord as heat produced depends on the resistance. Hence the cord of an electric heater does not glow whereas the heating element glows.

Example 13. Compute the heat generated while transferring 96000 coulomb of charge in one hour through a potential difference of 50 V. **[NCERT]**

Ans. It is given that Charge q = 96000 C and t = 1 hour, V = 50 V.

Heat generated is given by $H = VIt = V \times \frac{q}{t} \times t =$

$= V \times q = 50 \times 96000 = 4800kJ$

ELECTRIC POWER

Electric power is defined as the rate at which electrical work is done or the rate at which electrical energy is consumed or dissipated. The power P is given by

$$P = W/t = I^2R$$

Watt

Watt is the unit of power and is defined as the power consumed when 1 A of current flows at a potential difference of 1 V. Thus, Electric Power in Watts = Volt ampere.

When electrical energy is consumed at the rate of 1 J per second, power consumed is said to be 1 Watt.

Kilowatt hour

Kilowatt hour is the commercial unit of electric energy and is defined as the energy consumed when 1 KW is used for 1 hour.

1 kWh = 1 kW × 1 hour = 1000 watt × 3600 second = 3.6×10^6 joule

Electrical appliances are not connected in series

Different appliances need different values of current for their proper operation. Whereas, in a series circuit, the current is constant throughout the circuit. Also, when one component fails in a series circuit, the entire circuit is broken and none of the components work. On the other hand, a parallel circuit divides the current through the electrical gadgets.

Example 14. An electric bulb is rated 220 V and 100 W. When it is operated on 110 V, the power consumed will be:

(a) 100 W **(b) 75 W**

(c) 50 W **(d) 25 W** **[NCERT]**

Ans. *(d) 25 W*

Explanation: It is given that P = 100 W and V = 220 V. Therefore, we will first calculate resistance of the bulb using the formula

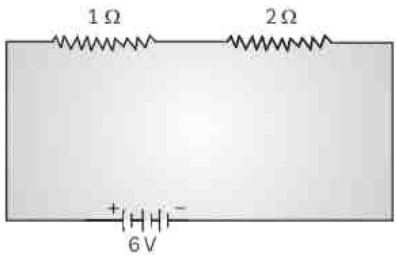
$$R = \frac{V^2}{P} = \frac{220 \times 220}{100} = 484 \text{ Ohm.}$$

When this bulb is operated on 110 V, power consumed will be

$$P = \frac{V^2}{R} = \frac{110 \times 110}{484} = \frac{12100}{484} = 25 \text{ W}$$

Example 15. Compare the power used in the 2 Ω resistor in each of the following circuits: (A) a 6 V battery in series with 1 Ω and 2 Ω resistors, and (B) a 4 V battery in parallel with 12 Ω and 2 Ω resistors. [NCERT]

Ans. (A) The figure below shows a 6V battery in series with 1 Ω and 2 Ω resistors.

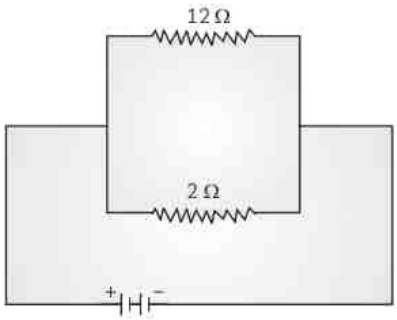


The total resistance in the series circuit = 1 Ω + 2 Ω = 3Ω.

Current, $I = V/R$ = 6/3 A = 2 A.

Power used in the 2 Ω resistor = $I^2R = 2 \times 2 \times 2$ = 8W

(B) The figure below shows a 4 V battery in parallelwith 12 Ω and 2 Ω resistors.



The current through the 2 Ω resistor = V/R = 4/2 = 2A (since the two resistors are connected in parallel, the potential difference across them is same).

Power used = $I^2R = 2 \times 2 \times 2$ = 8W.

Therefore, the power used in the 2 Ω resistors in both the circuits is same.

[1 mark]

Multiple Choice Questions

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

Ans. *(b)* 10^{-3} *A and* 10^{-6} *A.*

Explanation: An ampere is the SI unit of electric current

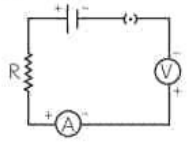
$$1\ A = 1000\ mA \text{ Or } 1\ mA = \frac{1A}{1000} = 10^{-3}A$$

$$\therefore \quad 1\ \mu A = 10^{-3} \times 10^{-3}A = 10^{-6}\ A$$

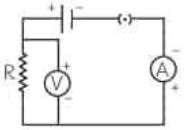
2. **A cylindrical conductor of length '*l*' and uniform area of cross-section '*A*' has resistance '*R*'. Another conductor of length 2.5 *l* and resistance 0.5 *R* of the same material has area of cross-section.**
(a) 5*A* **(b)** 2.5*A*
(c) 0.5*A* **(d)** $\frac{1}{5}A$
[CBSE 2020]

3. **Identify the circuit in which the electrical components have been properly connected.**

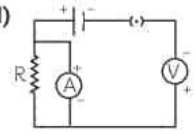
(I)



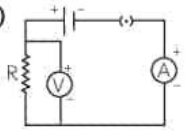
(II)



(III)



(IV)



(a) (I) **(b)** (II)
(c) (III) **(d)** (IV) **[CBSE 2013]**

Ans. *(b) (II)*

Explanation: In figure (I), the voltmeter is connected in series (not parallel). Similarly, in figure (III), the ammeter is in parallel which should be in series. In figure (IV), the negative terminal of battery has been connected to the positive terminal of the ammeter, whereas it should be connected to the negative terminal.

Related Theory

Essential conditions when components connected:
(1) The voltmeter should be connected in parallel.
(2) The ammeter should be connected in series.
(3) Positive terminals of the voltmeter and ammeter should be connected to the positive terminal of the cell and their negative terminals should be joined to the negative terminal of the cell.

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

5. **What is the minimum resistance which can be made using five resistors, each of $\frac{1}{5}\ \Omega$?**
(a) $\frac{1}{5}\ \Omega$ **(b)** $\frac{1}{25}\ \Omega$
(c) $\frac{1}{10}\ \Omega$ **(d)** 25 Ω
[CBSE 2015, 13, 12]

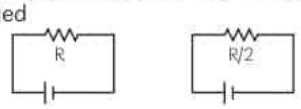
6. **The resistance of a resistor is reduced to half of its initial value. In doing so, if other parameters of the circuit remain unchanged, the heating effects in the resistor will become:**
(a) two times **(b) half**
(c) one-fourth **(d) four times**
[CBSE 2020]

Ans. *(a) two times*

Explanation: Resistance of a resistor *R* Ω

New resistance of a resistor $\frac{R}{2}\ \Omega$

All other parameters of the circuit remain unchanged



By applying Joule's law of heating
$H = I^2Rt$

As per Ohm's law $V = IR$ Or $I = \frac{V}{R}$

$$\therefore \quad H = \frac{V}{R} \times \frac{V}{R} \times R \times t \text{ Or } \frac{V^2}{R} \times t$$

Case I	Case II
$H = \frac{V^2}{R} \times t$	$H' = \frac{V^2}{R/2} \times t$
	$= \frac{V^2 \times 2}{R} \times t$
	$H' = H \times 2$

become two times if all other parameter of the circuit remain same.

7. **At the time of short circuit, the electric current in the circuit:**

(a) vary continuously

(b) does not change

(c) reduces substantially

(d) increases heavily **[CBSE 2020]**

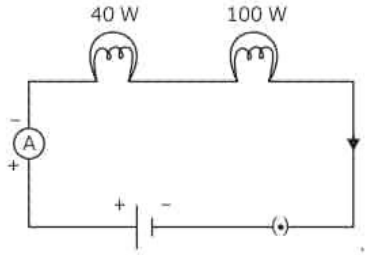
8. **Two bulbs of 100 Ω and 40 Ω are connected in series. The current through the 100 Ω bulb is 1 A. The current through the 40 Ω bulb will be:**

(a) 0.4 A **(b) 0.6 A**

(c) 0.8 A **(d) 1 A** **[CBSE 2020]**

Ans. *(d) 1 A*

Explanation:



In a series combination of resistors (bulbs) the current is the same in every part of the circuit as current does not change in series combination so both the bulbs get equal amount of current. Hence the current through the 40 Ω bulb will be 1A.

9. **When a 4 V battery is connected across an unknown resistor there is a current of 100 mA in the circuit. The value of the resistance of the resistor is:**

(a) 4 Ω **(b) 40 Ω**

(c) 400 Ω **(d) 0.4 Ω**

Ans. *(b) 40 Ω*

$V = IR, \quad V = 4\ V,$

$I = 100\ mA = 0.1\ A$

Hence $R = \frac{V}{I} = \frac{4}{0.1}\ \Omega = 40\ \Omega.$

[CBSE Marking Scheme 2019]

10. **The equivalent resistance of a series combination of two resistances is X Ohm. If the resistance are of 10 Ohm and 40 Ohm respectively, the value of X will be:**

(a) 10 Ohm **(b) 20 Ohm**

(c) 50 Ohm **(d) 40 Ohm** **[Diksha]**

expressed as:

(a) volt-ampere **(b) kilowatt-hour**

(c) watt-second **(d) joule-second**

[CBSE 2019]

12. **If the resistance of a certain copper wire is 1 Ω, then the resistance of a similar nichrome wire will be about:**

(a) 25 Ω **(b) 30 Ω**

(c) 60 Ω **(d) 45 Ω**

Ans. *(c) 60 Ω*

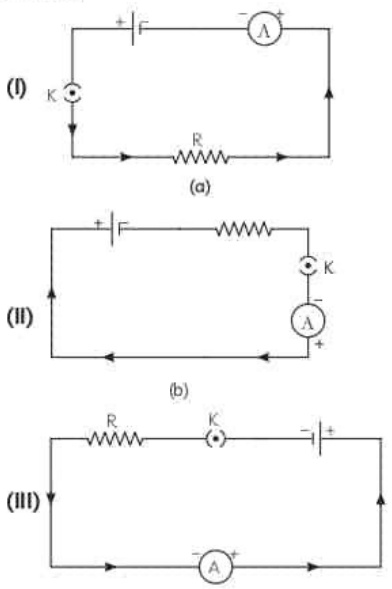
Explanation: If the resistance of a certain copper wire is 1 Ω, the resistance of a similar nichrome wire will be about 60 Ω because the resistivity of nichrome is 60 times the resistivity of copper.

13. **The resistivity of a certain material is 0.6 Ωm. The material is most likely to be:**

(a) an insulator **(b) a superconductor**

(c) a conductor **(d) a semiconductor**

14. **A cell, a resistor, a key and an ammeter are arranged as shown in the circuit diagrams of figure. The current recorded in the ammeter will be:**



(a) Maximum in (I)

(b) Maximum in (II)

(c) Maximum in (III)

(d) The same in all the cases

Ans. *(d) The same in all the cases*

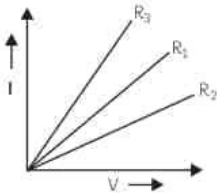
Explanation: In series connections the order of elements in the circuit will not affect the amount of current flowing in the circuit.

current is:

(a) galvanometer (b) ammeter

(c) voltmeter (d) potentiometer

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



(a) $R_1 = R_2 = R_3$ (b) $R_1 > R_2 > R_3$

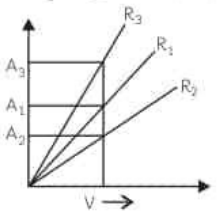
(c) $R_3 > R_2 > R_1$ (d) $R_2 > R_1 > R_3$

[CBSE 2020]

Ans. *(d)* $R_2 > R_1 > R_3$

Explanation: As is clear from the graph, the current for A_2 conductor is less than A_1 and A_1 is less than A_3. We can say $I_{A2} < I_{A1} < I_{A3}$

$R_2 > R_1 > R_3$ (As, R = V)



17. The maximum resistance which can be made using four resistors each of resistance $\frac{1}{2}\Omega$ is:

(a) 2 Ω (b) 1 Ω

(c) 2.5 Ω (d) 8 Ω **[CBSE 2020]**

Ans. *(a)* 2 Ω

Explanation: When a number of resistances are connected in series the resultant resistance is equal to the sum of the individual resistances and is greater than any individual resistance. Four resistors are given:

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

$$\therefore \quad R = R_1 + R_2 + R_3 + R_4$$

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

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

$$= \frac{4}{2} = 2\ \Omega$$

made using four resistors each of resistance $\frac{1}{2}$ Ω is 2 Ω.

18. A current of 2 A is drawn by a conductor on applying a potential difference of 6 V across its ends. The number of electrons passing through a cross section of the conductor and the heat generated in the conductor in 8 seconds is:

	Number of Electrons Passing in 8 s	Heat Generated in 8 s
(a)	1.6×10^{-20}	24 J
(b)	10^{20}	96 J
(c)	1.28×10^{-18}	3.6×10^6 J
(d)	10^{30}	96 J

19. The resistivity of four wires A, B, C and D are of the order of 10^{12}, 10^{-6}, 10^{-8} and 10^{14} respectively. If the wires are of equal lengths and equal areas of cross section, then select the row containing the correct information:

	Resistance	Nature
(a)	Resistance of C will be the least	C is the best conductor of electricity
(b)	Resistance of A will be the largest	A is a good conductor of electricity
(c)	Resistance of B will be the largest	B is a poor conductor of electricity
(d)	Resistance of D will be the least	D is the best conductor of electricity

20. Given below are four statements on resistance of a conductor. Select the incorrect statements:

(I) If in an electric circuit, the resistance is doubled the voltage also gets doubled.

(II) If in an electric circuit, the resistance is halved the current gets doubled.

(III) Variable resistance is a component used to regulate voltage without changing the current.

(IV) In an electric circuit, a device called rheostat is used to change the resistance in the circuit.

(a) Both (I) and (II)

(b) Both (I) and (III)

(c) Both (II) and (IV)

(d) (I), (III) and (IV)

Explanation: According to Ohm's law, V = IR.

Therefore, $I = \frac{V}{R}$.

It means that if resistance R is doubled, the current gets halved, but the voltage remains same. Similarly, if resistance is halved, current gets doubled.

21. **Given below are four statements about resistivity. Select the incorrect statements:**

(I) **Resistivity is a characteristic property of the material and varies with temperature.**

(II) **Resistivity depends on the length and area of cross section of the conductor.**

(III) **Metals and alloys have very low resistivity and are good conductors of electricity.**

(IV) **Insulators have low resistivity of the order of 10^{12} to 10^{17} Ω m.**

(a) **Both (I) and (II)**

(b) **Both (I) and (III)**

(c) **Both (II) and (III)**

(d) **Both (II) and (IV)**

22. **Select the correct statements from the statements given below:**

(I) **In a parallel circuit the current is constant throughout the electric circuit.**

(II) **In a parallel circuit the other components keep working even if one component fails.**

(III) **In a series circuit when one component fails, the circuit is broken and the other components stop working.**

(IV) **In a series circuit the current is divided among the electrical gadgets depending upon their resistance.**

(a) **Both (I) and (II)**

(b) **Both (II) and (III)**

(c) **Both (III) and (IV)**

(d) **(I), (III) and (IV)**

Ans. *(b) Both (II) and (III)*

Explanation: In a series circuit, the current is constant through the electric circuit and if one component fails, the other components also stop working. Whereas in a parallel circuit, the current is divided among the different components depending upon their resistance and if one component fails, the other components keep working.

23. **The unit of potential difference is:**

(a) **JC** (b) **J/C**

(c) **J** (d) **C/J**

Explanation: Potential difference between two points in an electric field of a given charge is defined as the work done in moving a unit positive charge from one point to another. As $V = \frac{W}{q}$, the unit of potential difference is Joule/Coulomb or J/C.

24. **If both the length of a conductor and its radius is doubled, the ratio of new resistance and original resistance will be:**

(a) **1 : 1** (b) **2 : 1**

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

25. **When a 2 Ω resistor is connected across the terminals of a 6 V battery, the charge (in coulombs) passing through the resistor per second is:**

(a) **0.5** (b) **2**

(c) **3** (d) **4**

Ans. *(c) 3*

Explanation: The charge passing through a resistor per second is the same as current passing through the resistor since current is defined as the rate of flow of charges. The current flowing is found by using Ohm's law, V = IR. Therefore, I = V/R = 6/2 = 3A, which is the same as charge passing in one second.

26. **A battery of 6V is connected in series with resistors of 0.1 ohm, 0.2 ohm, 0.3 ohm, 0.4 ohm and 2 ohm. How much current would flow through the 0.3 ohm resistor?**

(a) **0.895A** (b) **1.2 A**

(c) **2 A** (d) **3 A**

Assertion-Reason Questions

For the following questions, two statements are given—One labeled Assertion (A) and the other labeled Reason (R), select the correct answer to these questions from the codes (a), (b), (c) and (d) as given below:

(a) **Both (A) and (R) are true and (R) is correct explanation of the (A).**

(b) **Both (A) and (R) are true but (R) is not correct explanation of the (A).**

(c) **(A) is true but (R) is false.**

(d) **(A) is false but (R) is true.**

27. **Assertion (A): At high temperatures, metal wires have a greater chance of short circuiting.**

Reason (R) : Both resistance and resistivity of a material vary with temperature. **[CBSE 2020]**

correct explanation of the (A).

Explanation: At high temperatures, the free electrons start moving at a greater speed and more heat is evolved. The increased amount of heat melt the insulation of wires and wires have greater chance of short circuiting. Sometimes the short circuit may even melt the wire and it may cause fire.

Both resistance and resistivity vary with temperature. When the temperature is increased, the random motion of electrons increases. As a result the number of collision increases between atoms and electrons.

28. **Assertion (A) : When two ends of a metallic wire are connected across the terminals of a cell, then some potential difference is set up between its ends. The direction of electrons are from positive terminal to negative terminal of the cell.**

Reason (R) : Electrons are flowing through the conductors from its higher potential to its lower potential end. [Diksha]

29. **Assertion : A fuse wire is always connected in parallel with the mainline.**

Reason : If a current larger than the specified value flows through the circuit, fuse wire melts. [CBSE 2019]

30. **Assertion(A) : Electric appliances with metallic body have three pin connection, whereas an electric bulb has a two pin connection.**

Reason (R) : Three pin connection reduce heating of connecting wires. [Diksha]

Ans. *(c) (A) is true but (R) is false.*

Explanation: The three connection of electric appliances with metallic body are live wire, neutral wire and earth wire. The live and neutral wire supply electric current to the appliance, whereas the earth wire, which is connected to the metal body of the electric appliance, protects us from electric shock in case we touch the metal body of appliances. directly to the earth through the earth wire and we do not feel the electric shock.

On the contrary, three-pin connection do not reduce heating of connecting wires.

31. **Assertion (A) : In a purely resistive circuit, the source energy is dissipated in the form of heat.**

Reason (R) : The potential difference across the ends of a conductor is directly proportional to the current flowing through it.

32. **Assertion (A): Alloys are commonly used in electrical heating devices like electric ion and heater.**

Reason (R): Resistivity of an alloy is generally higher than that of its constituent metals but the alloys have low melting points then their constitutent metals. [CBSE 2020]

Ans. *(a) Both (A) and (R) are true and (R) is correct explanation of the assertion.*

Related Theory

- *Alloys have resistivity that of its constituent elements because alloys have better properties than that of metals. Resistivity is the property of material that explains how strongly the material opposes flow of electrons. Higher the resistivity, smaller will be the conductivity i.e. why alloys are used in electrical heating devices.*
- *Metals have higher melting point as the atoms are arranged in a regular manner and form a strong bond whereas alloys are made up of different metals. The different sizes of atoms in an alloy make their arrangement less regular than a pure metal. This makes the bonds between the atoms weakers and lowers the melting point.*

Very Short Answer Type Questions

33. **Define resistance. Give its S.I. unit. [CBSE 2019]**

34. **Define the term electrical resistivity of a material. [CBSE 2019]**

Ans. Electrical resistivity is defined as the electrical resistance of a conductor having cross-sectional area 1 m^2 and length 1m.

Related Theory

- *SI unit of electrical resistivity is ohm m (Wm)*
- *It is a characteristic property of the material and varies with temperature.*

insulators have very high resistivity.

35. **How will the heat produced in a resistor R change if its resistance is reduced to half of its initial value, other parameters of the circuit remain unchanged?**

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

Ans. Filament of bulb is made using strong metals having high melting points such as Tungsten which has melting point of 3380 °C, which is higher than the temperature at which it glows

37. **Should the resistance of an ammeter be low or high? Give reason.** **[CBSE 2014]**

parallel. If you are not provided with any other parameters (eg. Numerical value of I and R). What can be said about the voltage drop across the tow resistors?

Ans. Voltage-drop is same across both the resistors.

Explanation: In parallel connection, all the elements are connected between same two points hence the voltage drop across any number of resistors or other elements

Connected in parallel is same. Thus the voltage drop across the two resistors is same

39. **Some work is done to move a charge Q from infinity to a point A in space. The potential of the point ?A is given as V. What is the work done to move this charge from infinity in terms of Q and V?**

COMPETENCY BASED Questions (CBQs)

[1, 4 & 5 marks]

40. *The following table given below shows the resistivity of three materials X, Y and Z. Analyse the table and answer the following questions:*

Samples	X	Y	Z
Resistivity	3×10^{-9}	11.1×10^{-6}	18×10^{-17}

(A) Arrange the samples in increasing order of conductivity.

(B) Which of these is best conductor?

(C) Which are these is best insulator?

(a) X **(b) Y**

(c) Z **(d) None of these**

(D) Electrical resistivity of a given metallic wire depends upon:

(a) Its length

(b) Its thickness

(c) Its shape

(d) Nature of the material

Ans. (A) Conductivity is inversely propotional to resistivity so Y < X < Z.

(B) Z is the best insulator as it has least resistivity.

(D) *(d) Nature of the material*

Explanation: The resistivity of a material depends on the nature and the temperature of the conductor, but not its shape and size.

41. *Shivani 8 had studied in her class that an electric bulb consists of a filament made up of a metal having high melting point such as tungsten. Also, the bulbs are filled with a chemically inert gas such as nitrogen or argon to prolong the life of filament.*

A current of 1 A is drawn by a filament of anelectric bulb. The number of electrons passingthrough a cross-section of the filament in 16seconds would be roughly:

(a) 10^{20} **(b) 10^{16}**

(c) 10^{18} **(d) 10^{23}** **[NCERT]**

Ans. *(a) 10^{20}*

Explanation: Electric current, I = 1 *A*

Time, *t* = 16 seconds

No. of electrons, *n* = ?

We know that current is the amount of electric

conductor in 1 second.

$$I = \frac{Q}{t} = \frac{ne}{t}$$

$$\Rightarrow n = \frac{It}{e} = \frac{1 \times 16}{1.6 \times 10^{-19}}$$

$$\Rightarrow n = 10 \times 10^{19}$$

$$= 10^{20} \text{ electrons}$$

The number of electrons flowing is 10^{20} electrons.

42. *The following table given below shows the information about two heaters A and B. Analyse the table and answers the following questions:*

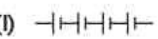
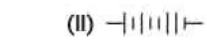
	Power	Voltage
Heater A	100W	220V
Heater B	150W	220V

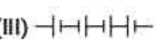
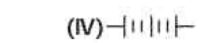
(A) Which Heater has higher resistance?

(B) If 1KWh is priced at 30 paise, which heater will be costlier if they run for 1 hours each?

43. *Prateek bought a new battery for his laptop as the earlier battery would not stay charged for more than 5 minutes. He learnt that a battery consisted of cells combined together in a particular manner.*

The proper representation of series combination of cells obtaining maximum potential is:

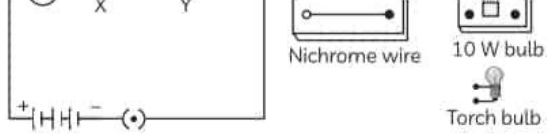
(I)  **(II)** 

(III)  **(IV)** 

(a) (I) **(b) (II)**

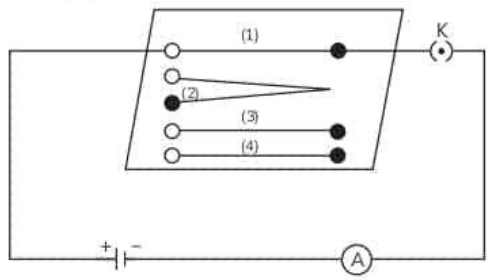
(c) (III) **(d) (IV)** **[CBSE 2013]**

44. *Take a nichrome wire, a torch bulb, a 10 W bulb and an ammeter (0 – 5 A range), a plug key and some connecting wires. Set up the circuit by connecting four dry cells of 1.5 V each in series with the ammeter leaving a gap XY in the circuit, as shown in Fig. below.*



Complete the circuit by connecting the nichrome wire in the gap XY. Plug the key. Note down the ammeter reading. Take out the key from the plug. Replace the nichrome wire with the torch bulb in the circuit and find the current through it by measuring the reading of the ammeter. Now repeat the above step with the 10 W bulb in the gap XY.

Next, complete an electric circuit consisting of a cell, an ammeter, a nichrome wire of length l [say, marked (1)] and a plug key, as shown in Fig. below.



Now, plug the key. Note the current in the ammeter. Replace the nichrome wire by another nichrome wire of same thickness but twice the length, that is 2l [marked (2) in the Fig. Note the ammeter reading. Now replace the wire by a thicker nichrome wire, of the same length l [marked (3)]. A thicker wire has a larger cross-sectional area. Again note down the current through the circuit.

Instead of taking a nichrome wire, connect a copper wire [marked (4) in Fig. 2] in the circuit. Let the wire be of the same length and same area of cross-section as that of the first nichrome wire [marked (1)].

[NCERT Activity 12.2, 12.3]

(A) The observation regarding ammeter readings on connecting the different components nichrome wire, torch bulb and a 10 W bulb in the gap XY is tabulated below.

Select the row containing the correct observation and its explanation.

	Observation	Explanation
(a)	Reading of ammeter will be same in all cases	Current flowing in a circuit depends only on the potential difference

	ammeter will be same in all cases	used are good conductors of electric current.
(c)	Reading of ammeter will be different for different components	All components resist the flow of electric current by different amounts
(d)	Reading of ammeter will be different for different components	All components offer equal resistance to the flow of electric current.

(B) Refer to the second activity and select the incorrect observations:

(I) The ammeter reading will be same in both cases when nichrome wire, marked (1), and copper wire, marked (4), both of length l and area of cross section A are connected one by one in the circuit.

(II) The ammeter reading will be different in both cases when nichrome wire, marked (1), and copper wire, marked (4), both of same length and cross section are connected one by one in the circuit.

(III) The current will be double when nichrome wire, marked (2), of length 2l and area of cross section A is connected as compared to nichrome wire, marked (1) of length l and area of cross section A.

(IV) The current will be double when nichrome wire, marked (3), of length l and area of cross section 2A is connected as compared to nichrome wire, marked (1) of length l and area of cross section A.

(a) Both (I) and (II)
(b) Both (II) and (III)
(c) Both (I) and (IV)
(d) (I), (III) and (IV)

(C) Select the incorrect statement:

(a) The flow of electrons within a conductor is restrained by the attraction of the atoms among which they move.

(b) The electrons are completely free to move within a conductor.

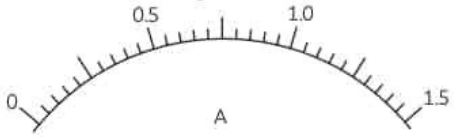
(c) The motion of electrons through a conductor is retarded by its resistance.

(d) A component of a given size that offers a low resistance is a good conductor.

(D) What will be the effect on current flowing in the circuit when length is made double?

(a) Current will remain same
(b) Current will become double
(c) Current will become half
(d) Current will become four times

(E) What will be the least count of an ammeter of range 0 – 1.5 A shown below:



(a) 0.1 A
(b) 0.2 A
(c) 0.02 A
(d) 0.05 A

Ans. (A) *(c) Observation: Reading of ammeter will be different for different components; Explanation: All components resist the flow of electric current by different amounts*

Explanation: The current is different for different components as certain components offer an easy path for the flow of electric current while the others resist the flow. The motion of electrons through a conductor isretarded by its resistance.

(B) *(a) Both (I) and (II)*

Explanation: The ammeter reading will be different in both cases when nichrome wire, marked (1), and copper wire, marked (4), both of same length and cross section are connected one by one in the circuit. This is because copper and nichrome are made up of different materials and resistance of a wire depends on the nature of the material. The current will be double when nichrome wire, marked (3), of length l and area of cross section 2A is connected as compared to nichrome wire, marked (1) of length l and area of cross section A. This is because a thicker wire offers lesser resistance and hence current flowing will be more through

wire. However, on increasing the length of a conductor to 2l, the resistance also becomes double and therefore current decreases to half of its value.

45. *Wires used for electrical connections have different properties and hence different ratings. So, one must select wires of proper rating to be used for different appliances as different appliances have different requirements.*

Electrical resistivity of a given metallic wire-depends upon:

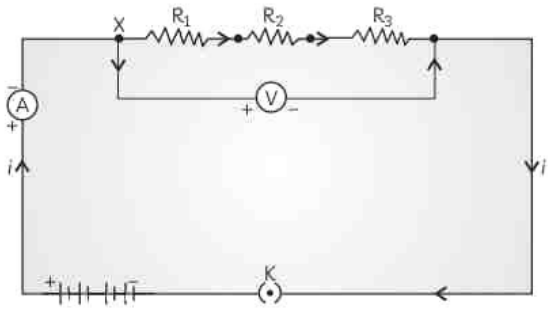
(a) Its length

(b) Its thickness

(c) Its shape

(d) Nature of the material

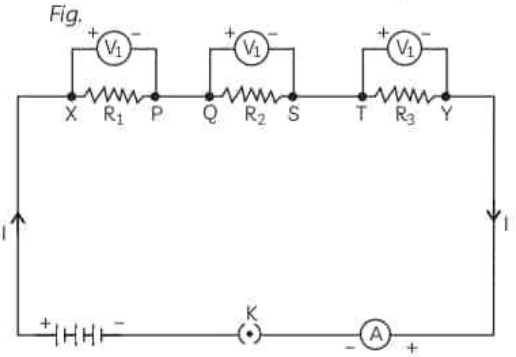
46. *Join three resistors of different values, say, 1 Ω, 2 Ω and 3 Ω etc., and a battery of 6 V in series. Connect them with a battery, an ammeter and a plug key, as shown in Fig. below.*



Plug the key. Note the ammeter reading. Change the position of ammeter to anywhere in between the resistors. Note the ammeter reading each time.

In the next activity, insert a voltmeter across the ends X and Y of the series combination of three resistors, as shown in Fig. below. Plug the key in the circuit and note the voltmeter reading. It gives the potential difference across the series combination of resistors. Let it be V. Now measure the potential difference across the two terminals of the battery. Compare the two values. Take out the plug key and disconnect the voltmeter. Now insert the voltmeter across

Fig.



Plug the key and measure the potential difference across the first resistor. Let it be V_1. Similarly, measure the potential difference across the other two resistors, separately. Let these values be V_2 and V_3, respectively.

[NCERT Activity]

(A) Refer to the first activity and circuit diagram at fig. 1. A student recorded his observations in a tabular form as shown below. Select the row containing correct observations/readings.

	Position of Ammeter	Ammeter Reading	Voltmeter Reading
(a)	Between battery and 1 Ω resistor as shown in figure	1 A	6 V
(b)	Between 1 Ω and 2 Ω resistor	6 A	2 V
(c)	Between 2 Ω and 3 Ω resistor	3 A	4 V
(d)	Between 3 Ω resistor and plug key	2 A	6 V

(B) Select the correct conclusion based n the observations recorded in activity 1 above:

(I) The resistances R_1, R_2 and R_3 are connected in series in the activity.

(II) In a series combination of resistors the current is different in different parts of the circuit.

(III) In a series combination of resistors the current is the same through each resistor.

(IV) In a series combination of resistors the potential difference is the same across each resistor.

(a) Both (I) and (II)

(b) Both (II) and (III)

(c) Both (I) and (III)

(d) Both (II) and (IV)

values of potential difference V, V_1, V_2 and V_3 are:

(a) V = 6 V, V_1 = 1 V, V_2 = 2 V, V_3 = 3 V

(b) V = 6 V, V_1 = 1 V, V_2 = 2 V, V_3 = 3 V

(c) V = 6 V, V_1 = 1 V, V_2 = 2 V, V_3 = 3 V

(d) V = 6 V, V_1 = 1 V, V_2 = 2 V, V_3 = 3 V

(D) **Which of the following relations for V and I is correct for a series combination of three resistors as shown above?**

(a) $I = I_1 + I_2 + I_3$

(b) $V = V_1 + V_2 + V_3$

(c) $\frac{1}{V} = \frac{1}{V_1} + \frac{1}{V_2} + \frac{1}{V_3}$

(d) $\frac{1}{I} = \frac{1}{I_1} + \frac{1}{I_2} + \frac{1}{I_3}$

(E) **Suppose in the above activity, each resistance is doubled. Select the correct observation:**

(a) The total current is doubled

(b) The potential difference is doubled

(c) The total current is halved

(d) The potential difference is halved.

Ans. (A) *(a) Position of Ammeter: Between battery and 1 Ω resistor as shown in figure; Ammeter Reading: 1A; Voltmeter Reading: 6 V.*

Explanation: The value of the current in the ammeter is the same and does not depend on its position in the electric circuit.

The total resistance resistance = $R_1 + R_2 + R_3$ = 6 Ω.

Therefore, reading of ammeter = I = V / R = 6/6 A = 1 A

(C) *(d) V = 6 V, V_1 = 1 V, V_2 = 2 V, V_3 = 3 V*

Explanation: The potential difference across the resistors R_1, R_2 and R_3 can be calculated by applying Ohm's law.

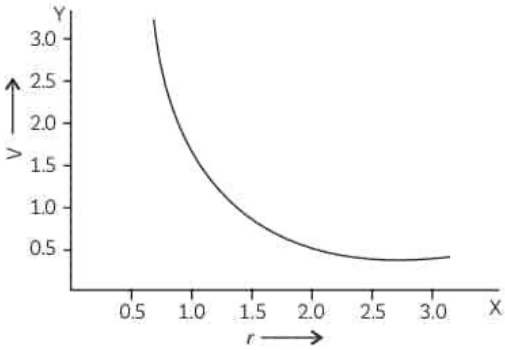
As current I = 1 A, $V_1 = IR_1$ = 1 V. Similarly, V_2 = 2 V and V_3 = 3V.

The potential difference V is equal to the sum of potential differences V_1, V_2, and V_3.

47. *Rahman wanted to change the electric bulb in his study room as he felt that the present bulb was not bright enough for him to study properly. So, he called the electrician. The electrician came and changed the bulb by holding the illuminated bulb with a piece of cloth as the bulb was very hot.*

The temperature of the filament of bulb is 2700°C when it glows. Why does it not getburnt up at such high temperature?

48. *Electric force is the force that pushes apart two like charges, or that pulls together two unlike charges. The electric potential (also called the electric field potential, potential drop, the electrostatic potential) is the amount of work energy needed to move a unit of electric charge (a Coulomb) from a reference point to the specific point in an electric field. The graph of variation of electric potential arising from a point charge Q with distance r from the charge q is shown below:*



Note: Both the charges Q and q are positive charges.

(A) **The conclusion that can be made from the above graph between electric potential (V) and distance (r) from the given charge is:**

(I) The electric potential decreases as the point charge Q is brought near the given charge q.

(II) The electric potential of a given charge q is inversely proportional to the distance of the point charge from the given charge.

(III) Work is done on a charge to move it closer to another charge of the same sign.

(IV) Less energy is required to bring the

charge q.

Which of the above conclusions are correct?

(a) Both (I) and (II)

(b) Both (II) and (IV)

(c) Both (I) and (III)

(d) Both (II) and (III)

(B) The unit of electric potential is:

(a) J/C (b) JC

(c) J/s (d) J/A

(C) The work done in moving a charge of 5 C across two points having a potential difference 12 V is:

(a) 2.4 J (b) 60 J

(c) 0.42 J (d) 120 J

(D) The instrument which is used to measure potential difference between two points and type of connection is given below. Select the row containing the correct information.

	Name of instrument	Type of connection
(a)	Ammeter	Series
(b)	Voltameter	Parallel
(c)	Voltmeter	Parallel
(d)	Voltmeter	Series

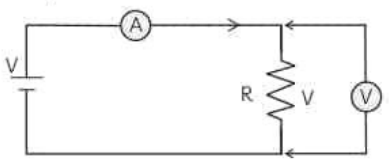
(E) When 120 J work is done to move 8 C charge from one point to another in an electric field, the potential difference developed between the two points is:

(a) 15 V (b) 960 J

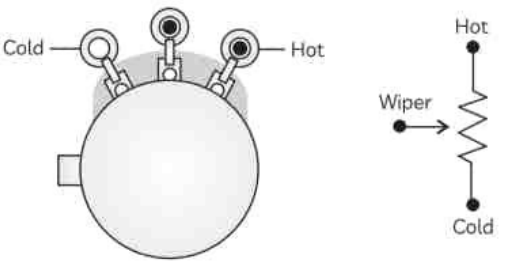
(c) 960 V (d) 7.5 V

Ans. (D) *(c) Name of instrument: Voltmeter; Type of connection: Parallel*

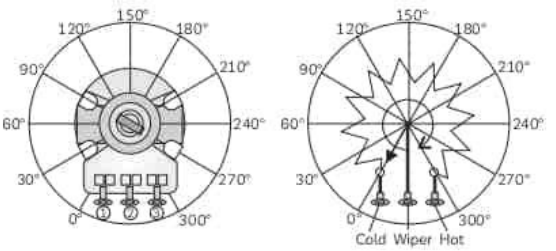
Explanation: The instrument used to measure potential difference between two points is voltmeter and is always connected in parallel across thepoints between which the potential difference is to be measured.



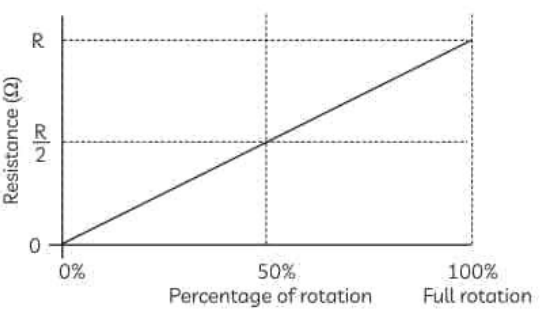
49. *Potentiometers, or "pots" for short, are used for volume and tone control in electric guitars. They allow us to alter the electrical resistance in a circuit at the turn of a knob. The guitar source, while the potentiometers provide the resistance. From Ohm's Law we can see how increasing resistance decreases the flow of current through a circuit, while decreasing the resistance increases the current flow. If two circuit paths are provided from a common voltage source, more current will flow through the path of least resistance.*



We can visualize the operation of a potentiometer from the drawing below.



Imagine a resistive track connected from terminal 1 to 3 of the pot. Terminal 2 is connected to a wiper that sweeps along the resistive track when the potentiometer shaft is rotated from 0° to 300°. This changes the resistance from terminals 1 to 2 and 2 to 3 simultaneously, while the resistance from terminal 1 to 3 remains the same. As the resistance from terminal 1 to 2 increases, the resistance from terminal 2 to 3 decreases, and vice-versa.



(A) When we turn the knob in the potentiometer or pots used in electric guitars, it alters the:

(b) Resistance in the circuit

(c) Voltage in the circuit

(d) Effective resistance of the circuit.

(B) Four statements are given below regarding the "cold" and "hot" terminals in the diagram of potentiometer.

Select the correct statements:

(I) The "cold" terminal refers to 0^0 rotation of potentiometer shaft and the "hot" terminal refers to 300^0 rotation of potentiometer shaft.

(II) The "cold" terminal refers to 300^0 rotation of potentiometer shaft and the "hot" terminal refers to 150^0 rotation of potentiometer shaft.

(III) When shaft is at "cold" terminal, resistance in the circuit is maximum, whereas it is minimum when shaft is at "hot" terminal.

(IV) When shaft is at "cold" terminal, resistance in the circuit is minimum, whereas it is maximum when shaft is at "hot" terminal.

(a) Both (I) and (III)

(b) Both (II) and (III)

(c) Both (I) and (IV)

(d) Both (II) and (IV)

(C) When the shaft undergoes 50% rotation, the effective resistance between its terminals is:

(a) R (b) R/3

(c) 2R (d) R/2

(D) The device that is used to change resistance in a circuit is:

(a) Rheostat

(b) Fuse

(c) Transformer

(d) Circuit breakers

(E) The table below lists the change in resistance of a wire on changing the physical parameter such as length (l) and area of cross section (A) of the wire. Select the row containing the incorrect answer:

	Change in Parameter	Change in Value of Resistance
(a)	Length is tripled	Resistance becomes three times
(b)	Area is halved	Resistance becomes double
(c)	Wire is pulled to double its length	Resistance becomes double
(d)	Diameter is doubled	Resistance becomes one fourth

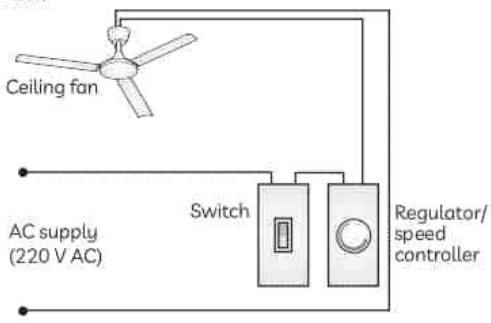
Ans. (B) *(c) Both (I) and (IV)*

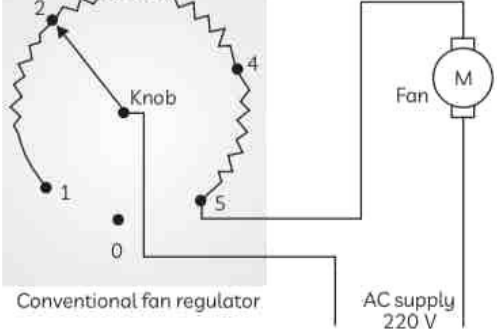
Explanation: When the potentiometer shaft is turned at 0°, it refers to the "cold" terminal and at this position the resistance is minimum. When the potentiometer shaft is turned at 300°, it refers to the "hot" terminal and at this position the resistance is maximum.

(D) *(a) Rheostat*

Explanation: In many cases it may be necessary to increaseor decrease the current in an electric circuit. A component used toregulate current without changing the voltage source is called variableresistance. In an electric circuit, a device called rheostat is used tochange the resistance in the circuit.

50. *Ohm law's application ranges from household appliances like heaters to the high tension wires and massive projects like rockets and spaceships. Ohm's law is used to maintain the desired voltage drop across the electronic components. Ohm's law is also used in dc ammeter and other dc shunts to divert the current. We can control the speed of the fans at our homes by moving the regulator to and fro. Here the current flowing through the fan is controlled by regulating the resistance through the regulator. A circular knob on the component can be rotated to achieve a variable resistance on the output terminals. For any specific value of the input, we can calculate the resistance, current and thus power flowing through Ohm's Law.*





(A) Refer to the figure-2 above. Select the row containing the correct information:

	Position of Regulator Knob	Effect on Fan Speed	Explanation
(a)	1	Slowest fan speed	Minimum resistance in circuit
(b)	1	Fastest fan speed	Minimum potential difference
(c)	3	Fan stops rotating	Current is cut off
(d)	5	Fastest fan speed	Minimum resistance in circuit

(B) The current flowing through a fan is controlled by:

(a) Regulating the voltage through the regulator

(b) Regulating the speed through the regulator

(c) Regulating the resistance through the regulator

(d) Regulating the resistivity through the regulator

(C) A resistance of 5 ohms is further drawn so that its length becomes double. Its resistance will now be:

(a) 20 ohms

(b) 10 ohms

(c) 7.5 ohms

(d) 5 ohms

(D) For a fixed supply voltage the current flowing through a conductor will decrease when

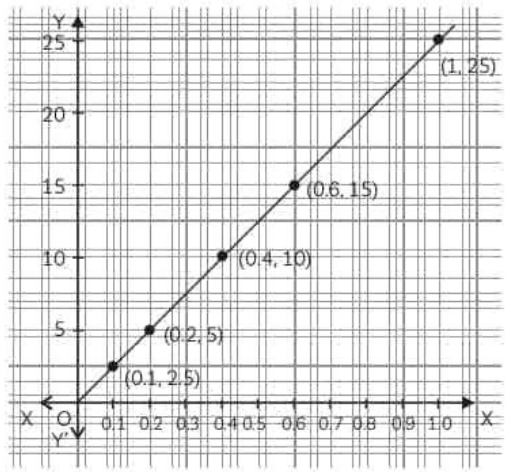
conductor is increased

(b) The length of the conductor is increased

(c) The length of the conductor is decreased

(d) The cross-sectional area is increased and length is decreased

(E) Observe the V-I graph plotted below and select the incorrect observations:



(I) The graph between current (I) and potential difference (V) is a straight line not passing through the origin.

(II) With increase in potential difference, current flowing through the conductor increases.

(III) The slope of the above graph gives the resistivity of the conductor.

(IV) The resistance of the given conductor is 25 Ohm.

(a) Both (I) and (II)

(b) Both (I) and (III)

(c) Both (II) and (III)

(d) Both (III) and (IV)

(C) *(a) 20 ohms*

Explanation: When a 5 ohm resistance is drawn so that its length becomes double, the area of cross section becomes half. As

$R = \rho\frac{l}{A} = 5$ Ohm, the new resistance will be

$R' = \rho\frac{2l}{A/2} = 4 \times \rho\frac{l}{A} = 4 \times 5 = 20$ Ohm.

kettles are common appliances used throughout the world. The heaters have a metal coil which has high resistance that permits a certain amount of current to flow through them to provide the required heat as per the Joule's law of heating. The electric kettle and irons have a lot of resistors in them. The resistors limit the amount of current to flow through them to provide the required amount of heat. The size of resistors used in them is determined by using Ohm's law.

(A) According to Joule's law of heating, the heat produced in a resistor in time t is:

(I) Directly proportional to the square of current for a given resistance

(II) Inversely proportional to the potential difference across the resistance

(III) Directly proportional to resistance for a given current

(IV) Inversely proportional to the time for which the current flows through the resistor.

Select the correct statements.

(a) Both (I) and (II)

(b) Both (II) and (III)

(c) Both (III) and (IV)

(d) Both (I) and (III)

(B) If the resistance of a resistor is reduced to half of its initial value, potential difference remaining unchanged, the heating effects in the resistor will

(a) Half (b) One fourth

(c) Two times (d) Four times

(C) Another common application of Joule's heating is the fuse used in electric circuits. Select the incorrect statement regarding fuse:

(a) It protects circuits and appliances by stopping the flow of any unduly high electric current.

(b) The fuse is placed in parallel with the device.

(c) It consists of a piece of wire made of a metal or an alloy of appropriate melting point.

(d) If a current larger than the specified value flows through the circuit, the fuse wire melts and breaks the circuit.

(D) Consider an electric iron which consumes 1 kW electric power when operated at 220 V. The table below gives the rating of ideal fuse that should be used in this case and the heat generated in the electric iron in 30 seconds.

	Ideal Rating of Fuse (A)	Heat Generated in 30 s (J)
(a)	4 A	3.0×10^4
(b)	10 A	1.0×10^4
(c)	5A	3.0×10^4
(d)	5A	3.6×10^6

(E) A resistance of 30 ohm is connected to a 6 V battery. The heat energy in joules generated per minute will be:

(a) 72 J (b) 144 J

(c) 288 J (d) 36 J

Ans. (A) *(d) Both (I) and (III)*

Explanation: According to Joule's law of heating, the heat produced in a resistor in time t is given by $H = Pt = VIt = I^2Rt \Rightarrow H \propto I^2, H \propto R, H \propto t$.

(E) *(a) 72 J*

Explanation: The heat generated in a resistor is given by Joule's law of heating, $H = I^2Rt$.

Here, $I = \frac{V}{R} = \frac{6}{30} = 0.2A$, R = 30 Ohm and t = 60 s.

Therefore, $H = (0.2)^2 \times 30 \times 60 = 72$ J

electric potential energy or kinetic energy of the charged particles. In general, it is referred to as the energy that has been converted from electric potential energy. In many cases it is necessary to calculate the energy usage by an electric device or a collection of devices, such as in a home. The electrical energy (E) used can be reduced either by reducing the time of use or by reducing the power consumption of that appliance or fixture. This will not only reduce the cost, but it will also result in a reduced impact on the environment. Improvements to lighting are some of the fastest ways to reduce the electrical energy used in a home or business. About 20% of a home's use of energy goes to lighting, while the number for commercial establishments is closer to 40%. A few common electrical appliances and their power ratings are given below:

	Load Types	Power Ratings
(1)	Light bulbs (incandescent	60W, 80W, 100W
(2)	Electric (steam) iron	2400W
(3)	Standing fan	70W
(4)	Water heater/Kettle	2000W
(5)	Electric blender	350W
(6)	Refrigerator	200W
(7)	Microwave oven	1200W
(8)	Hand dryer	1800W

(A) **Which of the following can be concluded from the table shown above?**

(I) **The energy consumption of an electrical appliance depends on the power rating and the usage time.**

(II) **The larger the power rating in the electrical appliance, the lesser is the energy used every second.**

(III) **The longer the usage time, the more electrical energy is consumed.**

(IV) **Appliances that have a heating effect usually have a high power rating and consume more electricity.**

(a) **Both (I) and (II)** (b) **Both (II) and (III)**

(c) **(I), (II) and (IV)** (d) **(I), (III) and (IV)**

(B) **An electrical water heater/kettle which is marked 2000 W, 220 V means that:**

(a) **The electric kettle will consume 2000 J of electrical energy every 1 second if it is connected to a 220 V supply.**

(b) **The electric kettle will consume 7.2 X 10^6 J of electrical energy every 1 supply.**

(c) **The electric kettle will consume 440 J of electrical energy every 1 second if it is connected to a 220 V supply.**

(d) **The electric kettle will consume 3.6 X 10^6 J of electrical energy every 1 second if it is connected to a 220 V supply.**

(C) **Students calculated the number of electrical units consumed daily by operating a hand dryer (Power rating 1800 W) for 2 h daily on a supply of 220 V, the total electrical energy consumed in the month of June (in Joule) and the cost of electricity for the month of June if one unit costs Rs. 5.50 and assuming that no other appliance is used.**

Select the row containing the correct entries.

	Number of Electrical Units Consumed daily	Electrical Energy Consumed in the Month of June (in Joules)	Total cost for Month of June (in Rs.)
(a)	108	12.96 X 10^6 J	Rs. 19.80
(b)	3.6	3.88 X 10^8 J	Rs. 594.00
(c)	3.6	12.96 X 10^6 J	Rs. 19.80
(d)	108	3.88 X 10^8 J	Rs. 594.00

(D) **The resistance of the refrigerator (Power rating 200 W, 220 V) is:**

(a) **44 kilo Ohm** (b) **44 Ohm**

(c) **242 Ohm** (d) **484 Ohm**

(E) **If the microwave oven and the electric blender of power ratings 1200 W and 350 W respectively are both used for 5 hours daily, the electrical energy consumed in a day is:**

(a) **6.0 units** (b) **7.75 units**

(c) **15.5 units** (d) **232.5 units**

Ans. (E) *(b) 7.75 units*

Explanation: The electrical energy consumed in a day is given by E=Pt = 1200 X 5 + 350 X 5 Wh = 7750 Wh = 7.75 kWh or 7.75 units

[2 marks]

53. What is the commercial unit of electrical energy? Represent it in terms of Joules.
[CBSE 2010]

Ans. The commercial unit of electric energy is kilowatt hour (kW h), commonly known as 'unit'.

1 kW h = 1000 watt × 3600 second

$= 3.6 \times 10^6$ watt second

$= 3.6 \times 10^6$ joule (J)

54. The electric power consumed by a device may be calculated by either of the two expressions $P = I^2R$ or $P = V^2/R$. The first expression indicates that it is directly proportional to R whereas the second expression indicates inverse proportionality. How can the seemingly different dependence of P on R in these expressions be explained?
[Diksha]

55. Two bulbs having power of 50 W and 25 W respectively are connected with the same source. Which has higher resistance? What is their ratio? **[Diksha]**

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

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

We have $P_1 = 50$ and $P_2 = 25$

$\therefore R_1 = \frac{V^2}{50}$ ohm

$R_2 = \frac{V^2}{25}$

ohm $= R_1 : R_2 \; \frac{V^2}{50} : \frac{V^2}{25} \; \frac{1}{2} : 1$

i.e., 50 W bulb has $\frac{1}{2}$ resistance than 25 W.

56. State Ohm's law.

Ans. Ohm's law states that under no same temperature, electric current flowing through an ideal conductor is directly proportional to the potential difference across its ends.

$V \propto I$

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

or $V = IR$

R is a constant for the given metallic wire at a given temperature and is called its resistance.

57. While studying the dependence of potential difference (V) across a resistor on the current (I) passing through it, in order to determine the resistance of the resistor, a student took 5 readings for different values of current and plotted a graph between V and I. He got a straight line graph passing through the origin. What does the straight line signify? Write the method of determining resistance of the resister using this graph. [CBSE 2019]

58. What would you suggest to a student if while performing an experiment he finds that the pointer/needle of the ammeter and voltmeter do not coincide with the zero marks on the scales when circuit is open? No extra ammeter/voltmeter is available in the laboratory. **[CBSE 2019]**

59. (A) In a given ammeter, a student saw that needle indicates 12^{th} division in ammeter while performing an experiment to verify Ohm's law. If ammeter has 10 divisions between 0 to 0·5 A, then what is the ammeter reading corresponding to 12th division?

(B) How do you connect an ammeter and a voltmeter in an electric circuit?

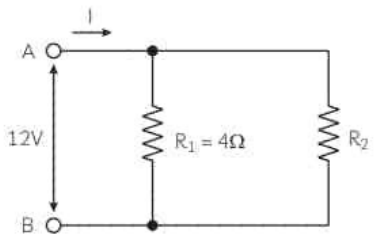
Ans. (A) Least count of ammeter $= \frac{0.5}{10} = 0.05$ A

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

(B) An ammeter is connected in series and a voltmeter is connected in parallel in an electric circuit.

[CBSE Marking Scheme 2019]

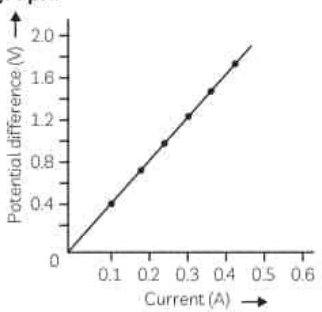
60. A student has two resistors-2 Ω and 3 Ω. She has to put one of them in place of R_2 as shown in the circuit. The current that she needs in the entire circuit is exactly 9A. Show by calculation which of the two resistors she should choose.



[CBSE SQP 2020]

[3 marks]

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



[CBSE 2020]

Ans. We infer from the graph that $\frac{V}{I}$ is a constant ratio. *i.e.*, V α I which is ohm's law. This constant ratio $\left(\frac{V}{I}\right)$ is called the resistance (R) of the conductor.

In 1827, a German physicist G. Siman Ohm found out the relationship between the current (I) flowing in a metallic wire and the potential difference across its terminals.

The potential difference (V) across the ends of a given metallic wire is in an electric circuit is directly proportional to the current flowing through it, provided its temperature remains the same.

$$V \alpha I$$

$$\frac{V}{I} = \text{Constant}$$

$$V = IR$$

62. **(A) Write the mathematical expression for Joule's law of heating.**

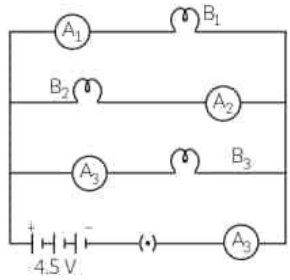
(B) Compute the heat generated while transferring 96000 coulomb of charge in two hours through a potential difference of 40 V. **[CBSE 2020]**

63. **B_1, B_2 and B_3 are three identical bulbs connected as shown in the figure. When all the three bulbs glow, a current of 3A is recorded by the ammeter A.**

(A) What happens to the glow of the other two bulbs when bulb B_1 gets fused?

(B) What happens to the reading of A_1, A_2, A_3 and A, when bulb B_2 gets fused?

(C) How much power is dissipated in the circuit when all the three bulbs glow together?



[CBSE 2015]

64. **Two resistors with resistance 5 Ohm and 10 Ohm respectively are to be connected to a battery of 6V so as to obtain:**

(A) Minimum current flowing

(B) Maximum current flowing

(i) How will you connect the resistors in each case?

(ii) Calculate the strength of total current in the circuit in the two cases.

Ans. **(A)** If we want minimum current, we will connect the resistors in series.

If we want maximum current we will connect them in parallel.

(B) $R_1 = 5$ ohms; $R_2 = 10$ ohms

(i) When connected in series

$$R = 10 + 5 = 15 \text{ ohms}$$

$$V = 6V$$

Therefore, $I = \frac{V}{R} = \frac{6}{15} = 0.4\ A$

When the resistors are connected in parallel

$$R = \frac{R_1 \times R_2}{R_1 + R_2} = \frac{50}{15}$$

$$= 3.33 \text{ ohms}$$

Therefore, $I = \frac{V}{R} = \frac{6}{3.33}$

$$= 1.801\ A$$

65. **Two conducting wires of the same material and of equal lengths and equal diameters are first connected in series and then in parallel in a circuit across the same potential difference. Find the ratio of heat produced in series and parallel combination.**

given resistor for the corresponding values of potential difference V across the resistor are given below:

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

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

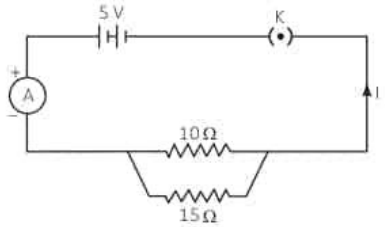
67. Answer the following questions:

(A) List a distinguishing feature between the resistance and resistivity of a conductor.

(B) A wire is stretched so that its length becomes 6/5 times its original length. If its original resistance is 25 ohm, find its new resistance and resistivity.

68. Study the following circuit and answer the questions that follows:

(A) State the type of combination of two resistors in the circuit.



(B) How much current is flowing through (i) 10 ohms and (ii) 15 ohms resistor?

(C) What is the ammeter reading?

69. Resistance of a metal wire of length 1 metre is 26 ohms. If the radius of the wire is 0.15 mm, calculate the resistivity of the material.

Ans. Given: $l = 1$ m; $r = 0.15$ mm $= 1.5 \times 10{-}4$ m

$$A = \pi r\ 2 = 3.14 \times 2.25 \times 10^{-8}$$
$$= 7.065 \times 10^{-8}\ m^2$$
$$R = r \times \frac{l}{A}$$

Now, resistivityr $= R \times \frac{A}{l}$

$$= 26 \times \frac{7.065 \times 10^{-8}}{1}$$
$$= 183.69 \times 10^{-8}\ \Omega m$$

Thus, the resistivity of the metal wire is 183.69 $\times 10^{-8}$ ρ m.

Related Theory

➥ *Resistance of a conductor depends on its length, on its area of cross-section and in the nature of material.*

➥ *inversely proportion to area of cross-section.*

➥ *ρ (rho) is a constant of proportionality and is known as resistivity.*

70. Answer the following:

(A) Why ammeter is always connected in series?

(B) Five dry cells each of 1.5 volt have internal resistance of 0.2, 0.3, 0.4, 0.5 and 1.2 ohms. When connected in series, what current will these five cells furnish through 10 ohm resistance?

Ans. (A) An ammeter is used to measure the current flowing through a circuit. We know that current remains same in series connection. Also the resistance of an ammeter is very small due to which it doesn't affect the current to be measured. So, an ammeter is always connected in series to measure current.

(B) Total voltage produced by the batteries

$$V = 5 \times 1.5 = 7.5\ V$$

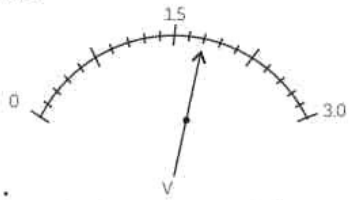
Total resistance

$$R = R_1 + R_2 + R_3 + R_4 + R_5$$
$$R = (0.2 + 0.3 + 0.4 + 0.5 + 1.2) + 10$$
$$= 12.6\ \Omega$$

Therefore, current

$$I = \frac{V}{R} = \frac{7.5}{12.6} = 0.595\ A.$$

71. Consider the scale of a voltmeter shown in the diagram and answer the following questions:



(A) What is the least count of the voltmeter?

(B) What is the reading shown by the voltmeter?

(C) If this voltmeter is connected across a resistor of 20 Ω, how much current is flowing through the resistor?

[CBSE 2019]

72. You have following material:

An ammeter (0-1A), a voltmeter (0-3V), a resistor of 20 Ω, a key, a rheostat, a battery of 3 V and seven connecting wires.

diagram to study the dependence of potential difference (V) across a resistor on the current (I) passing through it.

[CBSE 2018]

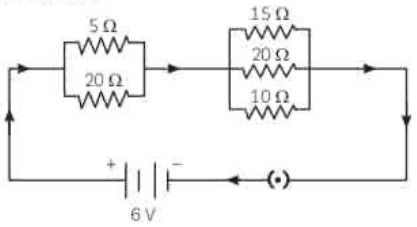
73. Justify the following statements:

(A) Tungsten is used exclusively for filaments of electric lamps.

(B) Series arrangement is not used for domestic circuits.

(C) Copper and aluminium wires are usually employed for electricity transmission.

combination and parallel combination of resistances?



(B) In the circuit diagram given below five resistances of 5 Ω, 20 Ω, 15 Ω, 20 Ω and 10 Ω, are connected as given in figure to a 6 V battery:

Calculate total resistance in the circuit.

LONG ANSWER Type Questions (LA)

[5 marks]

75. (A) Two lamps rated 100 W, 220 V and 10 Ω, 220 V are connected in parallel to 220 V supply. Calculate the total current through the circuit.

(B) Two resistors X and Y of resistances 2 Ω and 3 Ω respectively are first joined in parallel and then in series. In each case the voltage supplied is 5 V.

(i) Draw circuit diagrams to show the combination of resistors in each case.

(ii) Calculate the voltage across the 3 Ω resistor in the series combination of resistors. [CBSE 2020]

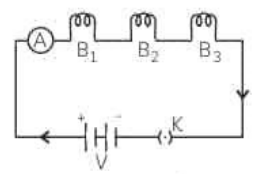
76. Three incandescent bulbs of 100 W each are connected in series in an electric circuit. In another set, three bulbs of the same wattage are connected in parallel to the same source.

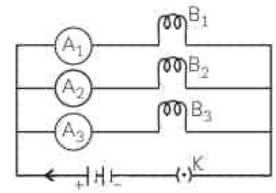
(A) Will the bulb in the two circuits glow with the same brightness? Justify your answer.

(B) Now, let one bulb in both the circuits get fused. Will the rest of the bulbs continue to glow in each circuit? Give reason.

[CBSE 2015, 14, 13, 12, 10]

Ans. (A) The two situations given in the question are shown in the figures given below:





For series combination:

Let us assume that the resistance of each bulb is R and the potential difference is V

Equivalent resistance in series combination,

$$R_{eq} = R + R + R = 3R.$$

Let current through each bulb in series combination be I_1 and voltage = V

By Ohm's law,

$$V = I_1 \times 3R$$

$$I_1 = \frac{V}{3R}$$

The power consumption of each bulb in series combination will be

$$P_1 = I^2R$$

$$= (I_1)^2 \times 3R = \left(\frac{V}{3R}\right)^2 \times 3R$$

$$= \frac{V^2}{3R} \quad \text{...(i)}$$

The resistance of each bulb = R
Voltage across each bulb = V
[as voltage remains the same in parallel combination]

$$I_1 = \frac{V}{R}$$

Power consumption of each bulb in parallel combination,

$$P_2 = \frac{V^2}{R} \quad ...(ii)$$

From equation (i) and (ii)

$$\frac{P_2}{P_1} = \frac{\frac{V^2}{R}}{\frac{V^2}{3R}}$$

$$\frac{P_2}{P_1} = \frac{3}{1}$$

$$P_2 = 3P_1$$

The resistance of the bulbs in series will be three times the resistance of one bulb. Therefore, the current in the series combination will be one-third the current of one bulb in parallel combination.

Therefore, bulb in parallel combination glows more brighter than each bulb in series combination.

(B) In series combination, there is only one path for the flow of current. So when one bulb gets fused, circuit is broken and hence the bulb stops glowing.

In parallel combination, each bulb has its own path for the flow of current. So when one bulb gets fused, other bulbs will continue to glow as the current is flowing in the circuits of these bulbs.

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

78. Two identical resistors, each of resistance 15 Ω, are connected in (A) series, and (B) parallel, in turn to a battery of 6 V. Calculate the ratio of the power consumed in the combination of resistors in each case.
[CBSE 2020]

Ans. $R = 15\ \Omega$
$V = 6$ V
resistors are given so $R_1 = R_2$

(A) In series

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

(B) In Parallel

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

$$= \frac{1}{15} + \frac{1}{15} = \frac{2}{15}$$

$$\therefore \quad R_P = \frac{15}{2}\Omega$$

Power when resistors are connected in series $P_S = \frac{V^2}{R_s} = \frac{6\times6}{30}$

$$P_S = \frac{6}{5}\Omega = \frac{6\times6}{60} = \frac{36}{30}\Omega$$

Power when resistors are connected in parallel

$$P_P = \frac{V^2}{R_p}$$

$$= \frac{6\times6\times2}{15} = \frac{72}{15}\ \Omega$$

The Ratio of power consumed in combination of reactors in the two cases

$$\frac{P_s}{P_p} = \frac{36}{30} \div \frac{72}{15} \text{ Or } \frac{1}{4}$$

$$\therefore \quad PS : PP = 1 : 4$$

79. (A) A 6 Ω resistance wire is doubled on itself. Calculate the new resistance of the wire.

(B) Three 2 Ω resistors A, B and C are connected in such a way that the total resistance of the combination is 3 Ω. Show the arrangement of the three resistors and justify your answer.
[CBSE 2020]

80. (A) Define electric power. An electrical device of resistance R is connected across a source of voltage V and draws a current I.
Derive an expression for power in terms of current and resistance.

V and 60 W; 220 V are connected in parallel to an electric mains of 220 V. Find the current drawn by the bulbs from the mains. [CBSE 2019]

81. (A) Define electrical energy with S.I. unit?

(B) A household uses the following electric appliance;

(i) Refrigerator of rating 400w for ten hour each day.

(ii) Two electric fans of rating 80w each for twelve hours each day.

(iii) Six electric tubes of rating 18w each for six hours each day.

Calculate the electricity bill of the household for the month of June if the cost per unit of electric energy is ₹ 3.00. [Diksha]

Ans. (A) The work done by a source of electricity to maintain current in a circuit is known as electrical energy. Its S.I. unit is Joule.

(B) (i) Electricity consumed by refrigerator

= Power × Time

= 400 × 10

= 4000 Wh

= 4 kWh

(ii) Electricity consumed by two fans

= Power × Time

= 80 × 2 × 12

= 1920 Wh

= 1.92 kWh

(iii) Electricity consumed by six electric tubes

= 6 × 18 × 6

= 648 Wh

= 0.648 kWh

Total energy consumed in one day

= 4 + 1.92 + 0.648

= 6.548 kWh

Total energy consumed in one month

= 6.548 × 30

= 197.04 kWh

Cost of 1 unit (kWh) = ₹ 3.00

Cost of 197.04 kWh = 197.04 × 3.00

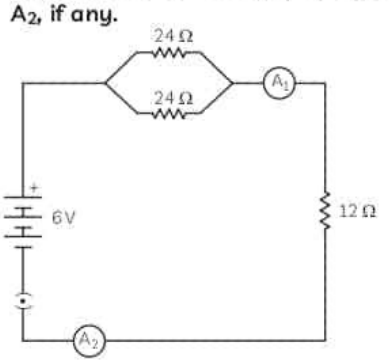
Total electricity bill = ₹ 591.12

an experiment that the same current flows through every part of the circuit containing three resistors R_1, R_2 and R_3 in series connected to a battery of V volts?

(B) Study the following circuit and find out:

(i) Current in 12 Ω resistor.

(ii) Difference in the readings of A_1 and A_2, if any.



[CBSE 2019]

83. (A) Three resistors of resistances R_1, R_2 and R_3 are connected (i) in series, and (ii) in parallel. Write expressions for the equivalent resistance of the combination in each case.

(B) Two identical resistors of 12 Ω each are connected to a battery of 3 V. Calculate the ratio of the power consumed by the resulting combinations with minimum resistance and maximum resistance.

[CBSE 2019]

84. (A) With the help of a suitable circuit diagram prove that the reciprocal of the equivalent resistance of a group of resistances joined in parallel is equal to the sum of the reciprocals of the individual resistances.

(B) In an electric circuit two resistors of 12 Ω each are joined in parallel to a 6 V battery. Find the current drawn from the battery. [CBSE 2019]

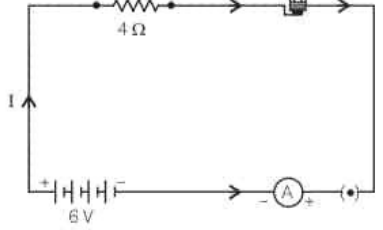
85. An electric lamp of resistance 20 Ω and a conductor of resistance 4 Ω are connected to 6 V battery as shown in the circuit. Calculate:

(A) the total resistance of the circuit,

(B) the current through the circuit,

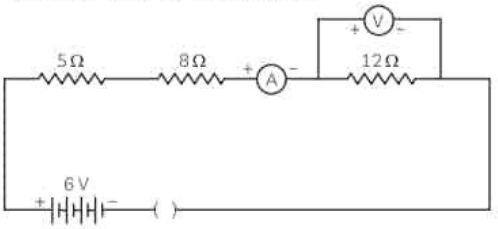
(C) the potential difference across the (i) electric lamp and (ii) conductor, and

(D) power of the lamp



[CBSE 2019]

86. **Consider the following circuit:**



What would be the readings of the ammeter and the voltmeter when key is closed?

Give reason to justify your answers.

[CBSE 2018]

Ans. The three resistors are connected in series. The effective resistance of 3 resistors R_1, R_2 and R_3 connected in series is given by :

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

The effective resistance = 5 + 8 + 12 = 25 Ohm

Total current flowing I in the circuit is given by

Ohm's law = $I = \frac{V}{R} = \frac{6}{25} A$

As the current flowing through the resistors connected in series is same, the current flowing through the Ammeter = I = 0.24 A.

Reading of ammeter = 0.24 A.

The potential difference V is equal to the sum of the potential difference V_1, V_2 and V_3 across the individual resistors R_1, R_2 and R_3 respectively. That is,

$$V = V_1 + V_2 + V_3$$

As the voltmeter is connected across the 12 Ohm resistor or R_3, we will calculate the potential difference V_3 across R_3.

Using Ohm's law, $V_3 = IR_3 = 0.24 \times 12V = 2.88V$.

Reading of Voltmeter = 2.88 V

87. **(A)** **Consider a conductor of resistance 'R', length 'L', thickness'd' and resistivity ' '. 5 Now this conductor is cut into four equal parts. What will be the new resistivity of each of these parts? Why?**

are connected in:

(A) Parallel

(B) Series

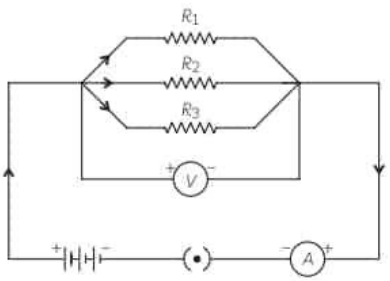
(C) Out of the combinations of resistors mentioned above in the previous part, for a given voltage which combination will consume more power and why?

88. **In the circuit given below, the resistors R_1, R_2 and R_3 have the values 10 Ω, 20 Ω and 30 Ω respectively, which have been connected to a battery of 12 V. Calculate:**

(A) the current through each resistor,

(B) the total circuit resistance, and

(C) the total current in the circuit.



Ans. Given:

$R_1 = 10\ \Omega$; $R_2 = 20\ \Omega$; $R_3 = 30\ \Omega$

According to Ohm's law,

$V = IR$ Given $V = 12$ V

(A) Current through resistor R_1:

$$I_1 = \frac{V}{R_1} = \frac{12}{10} = 1.2 \text{ A}$$

Current through resistor R_2:

$$I_2 = \frac{V}{R_2} = \frac{12}{20} = 0.6 \text{ A}$$

Current through resistor R_3:

$$I_3 = \frac{V}{R_2} = \frac{12}{30} = 0.4 \text{ A}$$

(B) Total circuit resistance, R

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

$$\frac{1}{R} = \frac{1}{10} + \frac{1}{20} + \frac{1}{30}$$

$$\frac{1}{R} = \frac{11}{60}$$

$$R = \frac{60}{11} = 5.45\ \Omega$$

$I = I_1 + I_2 + I_3$

$= 1.2 + 0.6 + 0.4 = 2.2$ A

[CBSE Marking Scheme 2019]

89. (A) **Name an instrument that measures electric current in a circuit. Define unit of electric current.**

(B) **How is static electricity different from current electricity?**

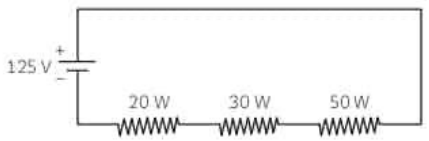
(C) **Mention some important uses of electricity in our daily life.**

90. (A) **On what factors does the resistance of a conductor depend?**

(B) **Give one example to show how the resistance depends on the nature of material of the conductor.**

(C) **Calculate the resistance of an aluminium cable of length 10 km and diameter 2.0 mm if the resistivity of aluminium is $2.7 \times 10^{-8}\ \Omega$ m.**

91. **Determine the following quantities for the circuits shown below:**



(A) the equivalent resistance

(B) the total current from the power supply

(C) the current through each resistor

(D) the voltage drop across each resistor and

(E) the power dissipated in each resistor

92. **What is Joule's heating effect? How can it be demonstrated experimentally? List its four applications in daily life.**

Ans. Joule's heating effect: When an electric current is passed through a high resistance metallic wire, like nichrome wire, the resistance wire becomes very hot and produces heat. This effect is known as heating effect of current or Joule's heating effect.

Joule's law of heating states that the heat H produced in a conductor of resistance R due to current flowing through it for time t is $H = I_2Rt$

A simple experiment to demonstrate heating effect of current is that if we switch on the bulb hot. This shows that when electric current flows through a metallic conductor, heat is produced in it.

Applications of Joule's heating effect in daily life are:

(1) Electric fuse is a safety circuit device works on this principle. Electric fuse in the electric circuit melts when large current flows in the circuit.

(2) Electric iron, electric heater and water heater etc. work on the principle of heating effect of current.

(3) Electric bulb glows when electric current flows through the filament of the bulb.

93. **(A) An electric bulb is rated at 200 V; 100 W. What is its resistance?**

(B) Calculate the energy consumed by 3 such bulbs if they glow continuously for 10 hours for complete month of November.

(C) Calculate the total cost if the rate is ₹ 6.50 per unit. **[CBSE SQP 2020]**

Ans. (A) $V = 220$ V

$P = 100$ W

$R = ?$

$P = VI$

$V = IR$

$I = I$ ...(ii) $V = \frac{V}{R}$

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

$R = \frac{V^2}{R} = \frac{200 \times 200}{100}$

$R = 400$ W

(B) $P = 100$ W (given 3 such bulbs) or $\frac{100}{1000} =$ 0.1 kW

No. of bulbs = 3

time t = 10 hours

Number of days in the month of November = 30

$E = P \times t$

Total energy consumed by 3 bulbs in 30 days

$= 3 \times 0.1 \times 10 \times 30 = 90$ kWh

Hence, the energy consumed by 3 such bulbs for the month of November will be 90 kWh.

Rate of per unit = ₹ 6.50 per unit

1 kWh = 1 unit

∴ 90 kWh = 90 units

Tost cost = 90 × 6.50 = ₹ 585.00

Hence, the total of operating 3 such bulbs will ₹ 585.

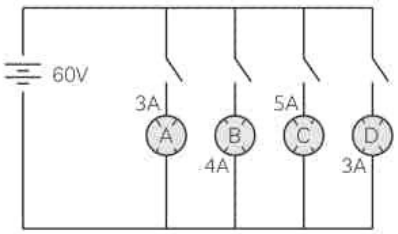
94. **(A) What is meant by the statement, "The resistance of a conductor is one ohm"?**

(B) Define electric power. Write an expression relating electric power, potential difference and resistance.

(C) How many 132 W resistors in parallel are required to carry 5 A on a 220 V line?

[CBSE 2020]

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



questions.

(A) Vi/hat kind of combination are the lamps airanged in (series or parallel)?

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

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

(D) Find out the total resistance of the circuit.

[CBSE SQP 2020]

Ans. (A) The lamps are in parallel.

(B) Advantages : If one lamp is faulty. It will not affect the working of the other lamps. They will also be using the full potential of the battery as they are connected in parallel.

The lamp with the highest power will glow the brightest.

P = VI

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

The total current in the circuit = 3 + 4 + 5 + 3 A = 15A

The Voltage = 60V

V= Ir and hence R =

VERY SHORT ANSWER Type Questions

[1 mark]

1. State the S.I. unit of potential difference and name the device used to measure it.

Ans.

The S.I. unit of potential difference is 'volts' in honour of Alessandro Volta.

Voltmeter is a device that is always connected in parallel in a circuit to measure the voltage.

[CBSE Topper 2019]

SHORT ANSWER Type-II Questions (SA-II)

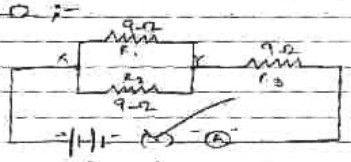
[3 marks]

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

Ans.

Let R be the resistor of 9 Ω.

(i) For 13.5 Ω :-



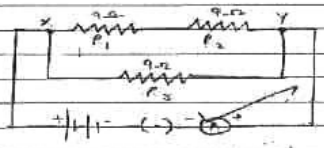
For parallel combination, $\frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R_2}$

$\therefore \frac{1}{R_p} = \frac{1}{9} + \frac{1}{9} = \frac{2}{9}$ $\therefore R_p = \frac{9}{2}\Omega = 4.5\Omega$

Resistance of total combination (R_T) 1½

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

(ii)



$R_S = R_1 + R_2 + R_3$ ---- [Law of combination of resistors in series]

$R_S = R_1 + R_2 = 9 + 9 = 18\Omega$

$\frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R_2}$ ---- [Law of combination of resistors in parallel]

$\frac{1}{R_p} = \frac{1}{R_S} + \frac{1}{R_3} = \frac{1}{18} + \frac{1}{9} = \frac{1+2}{18} = \frac{3}{18}$

$R_p = \frac{18}{3} = 6\Omega$ 1½

[CBSE Topper 2018]

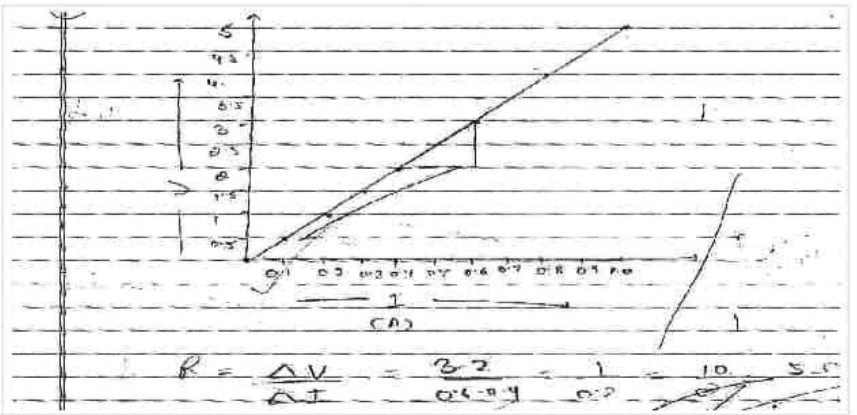
[5 marks]

3. The values of current (I) flowing through a given resistor of resistance (R), for the corresponding values of potential difference (V) across the resistor are as given below:

V (volts)	0.5	1.0	1.5	2.0	2.5	3.0	4.0	5.0
I (amperes)	0.1	0.2	0.3	0.4	0.5	0.6	0.8	1.0

Plot a graph between current (I) and potential difference (V) and determine the resistance (R) of the resistor.

Ans.

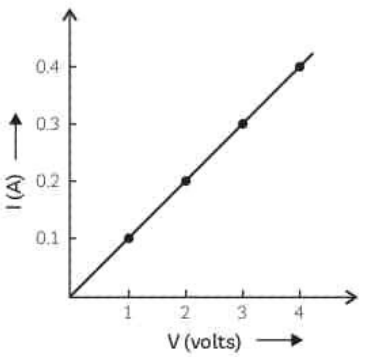


[CBSE Topper 2018]

4. In the experiment to study the dependence of current (I) on the potential difference (V) across a resistor, a student obtained a graph as shown.

(i) What does the graph depict about the dependence of current on the potential difference?

(ii) Find the current that flows through the resistor when the potential difference across it is 2·5 V.



Ans.

(i) As the graph depicts, the resistance (slope) is constantly increasing which explains that the potential difference and the current are proportionately increasing.

∴ $I \propto V$ [Based on Ohm's Law]

Resistance for a particular conductor at a particular temperature is constant. ∴ $R = \frac{V}{I} = \frac{1}{0.1} = 10\ \Omega$ or [Avg. $R = \frac{1+2+3+4}{0.1+0.2+0.3+0.4} = \frac{10}{1} = 10\ \Omega$]

(Ohm's Law) $I = \frac{V}{R}$ ∴ $I = \frac{2.5}{10} \times \frac{1}{10} =$ [0.25 A]

[CBSE Topper 2019]