Electricity

- A form of energy resulting from the existence of charged particles (such as electrons or protons), either statically as an accumulation of charge or dynamically as a current.
- In simpler terms, electricity is the flow of electric charge. When electrons move through a conductor, like a wire, a current is established, and this flow of electric charge is what we commonly refer to as electricity.
- A secondary energy source, meaning it is converted from other sources of energy, such as coal, natural gas, oil, nuclear, or renewable sources like sunlight, wind, and hydropower.

Types of Electricity

- Static electricity - A result of an imbalance between positive and negative charges in an object. The build up of such charges on an object which when released through a circuit causes a discharge of static electricity. Ex - Rubbing a balloon on hair, Walking on a carpet and getting a shock, Van de Graff generator etc.
- Current electricity – It is the amount of charges flowing (continuous flow of charges) through a particular area in unit time. Also, can be defines as rate of flow of electric charges. Ex - Turning on a Light Bulb, Charging a Smartphone etc.

Electric current

- It is the rate of flow of charges in a circuit.
- At the time, the existence of electrons were not known. So, earlier electric current was considered to be the flow of positive charges and the direction of flow of positive charges was taken to be the direction of electric current. This is called conventional current.
- Conventionally, in an electric circuit the direction of electric current is taken as opposite to the direction of the flow of electrons, which are negative charges. This is called electron flow theory and this is what exactly happens.

Note: https://www.youtube.com/watch?v=MUh_dOcqgVw

- If 'Q' is the net charge that is flowing across the cross-section of a conductor in time 't' , then the current flowing across the conductor –

$$I = Q/t$$

and, $Q = ne$

where, n = number of electrons

e = charge of one electron, i.e., 1.6×10^{-11} C

  - S.I unit of charge is Coulomb (C) which is 6×10^{18} electrons
  - The electric current is expressed by a unit called ampere (A), named after the French scientist, Andre-Marie Ampere (1775–1836)
  - 1 A = 1C/1s

Potential difference

- For flow of charges in a conducting metallic wire, the gravity, of course, has no role to play; the electrons move only if there is a difference of electric pressure – called the potential difference along the conductor.
- When a cell or a battery is connected to a conducting circuit element, the potential difference sets the charges in motion in the conductor and produces an electric current.

- We define the electric potential difference between two points in an electric circuit carrying some current as the work done to move a unit charge from one point to the other Potential difference or p.d (V) between two points = Work done (W)/Charge (Q)
- The potential difference in a circuit is measured by an instrument called Voltmeter

$$p.d\ (V) = W/Q$$

S.I unit of p.d is volt or V

$$1\ V = 1J/1C$$

$$\text{dimension} = [ML^2T^{-3}I^{-1}]$$

Conductors and Non-Conductors

- Conductors – These are materials that allow the flow of electric charge (usually in the form of electrons) with little resistance. The electrons are loosely bound to atoms, allowing them to move freely in response to an electric field. Ex - copper, aluminum, silver, gold, graphite and some electrolytes (in liquid form) etc
- Non conductors/Insulators – Such material do not allow the easy flow of electric charge through them. The electrons are tightly bound to atoms, making it difficult for them to move in response to an electric field. Ex – rubber, glass, ceramics, wood etc

Ohm's law

- It gives the linear relationship between the current 'I', flowing in a metallic wire and the potential difference 'V' across its terminals.
- Given by German physicist Georg Simon Ohm in 1827

$$V \propto I$$

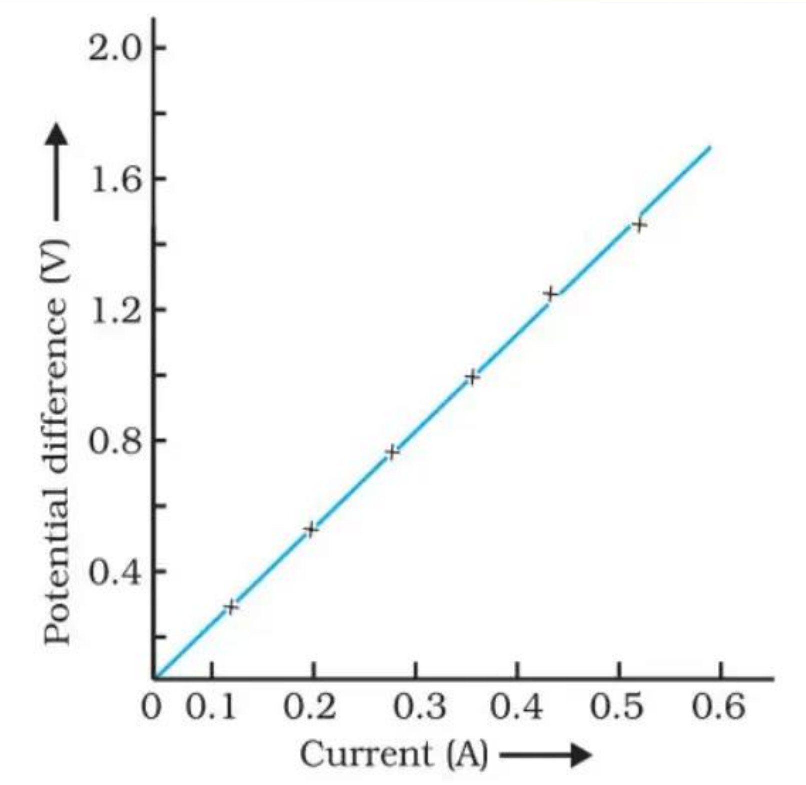
$$V/I = \text{constant}$$

$$= R$$

$$V = IR$$

here, 'R' is the constant term called the resistance of the conducting metallic wire.

$$R = V/I$$



here, is a graphical representation of Ohm's law of a conducting material and it is clearly a linear in nature

Resistance

- Resistance is a fundamental electrical property that quantifies how much a material or device opposes the flow of electric current.
- Materials with high resistance (insulators) impede the flow of electric current, while those with low resistance (conductors) allow current to flow more easily.
- The resistance in a circuit is measured by a device called rheostat.

Factors on which resistance depend

- Resistance of the conductor –
  - is directly proportional to its length (l)
  - indirectly proportional to its area of cross-section (A)
  - on the nature of its material

$$R \propto l$$

$$R \propto 1/A$$

$$\text{then, } R \propto l/A$$

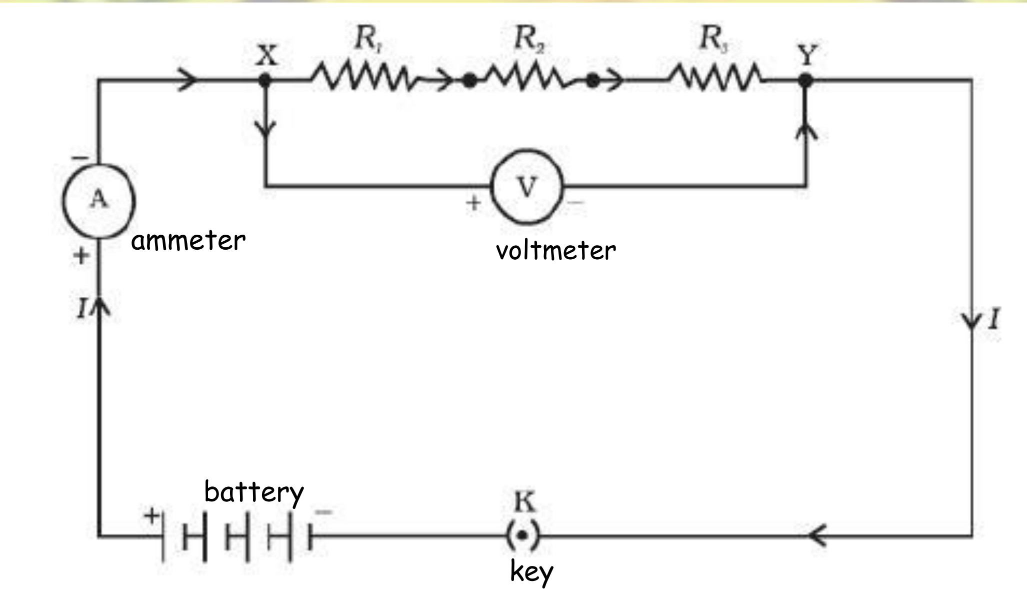
$$R = \rho\,(l/A)$$

here, ρ (rho) is a proportionality constant and it is the electrical resistivity of the material of the conductor.

- S.I unit of ρ (rho) is Ωm (ohm-meter)
- The metals and alloys have very low resistivity in the range of 10^{-8} Ω m to 10^{-6} Ω m. They are good conductors of electricity.
- Insulators like rubber and glass have resistivity of the order of 10^{12} to 10^{17} Ω m.

Series combination of Resistors

- In series combination of resistors, the current is same in every part of the circuit or the same current flows through out each resistor.



A series combination of three resistors

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- Total p.d across a combination of resistors in series is equal to the sum of potential difference across the individual resistors -

$$V = V_1 + V_2 + V_3$$

applying Ohm's law, $V = IR$

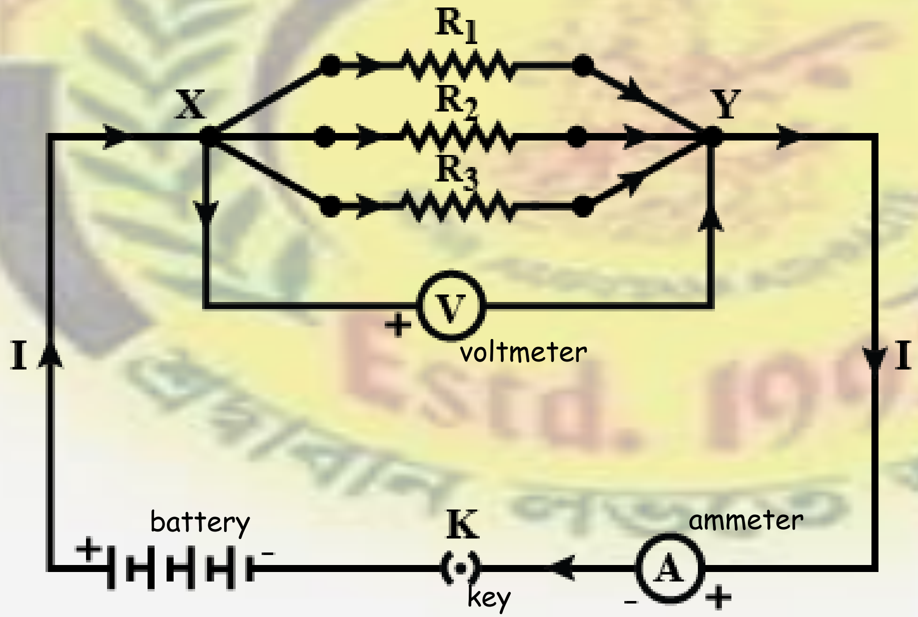
$$IR = IR_1 + IR_2 + IR_3$$

or, $R = R_1 + R_2 + R_3$

- Conclusion - When several resistors are joined in series, the resistance of the combination R equals the sum of their individual resistances, R_1, R_2, R_3, and is thus greater than any individual resistance.

Parallel combination of Resistors

- In parallel combination of resistors, the voltage remains the same or constant in every part of the circuit.



A parallel combination of three resistors

- Total current 'I' in the circuit is equal to the sum of the separate currents through each branch of the combination –

$$I = I_1 + I_2 + I_3$$

applying Ohm's law, $I = V/R$

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

or, $1/R = 1/R_1 + 1/R_2 + 1/R_3$

- Conclusion - 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.

Heating effect of electric current

- To maintain current in the circuit, the source has to keep on expanding its energy. A part of this energy is used in useful works, like rotating the blades of fan, while rest of the energy may be expanded in heat to raise the temperature of gadget.
- If the electric circuit is purely resistive, that is, a configuration of resistors only connected to a battery; the source energy continually gets dissipated entirely in the form of heat. This is known as the heating effect of electric current.

Joule's law of heating

- Let 'I' be the current, 'R' be the resistance in the circuit and 't' be the time during which the current flows in the circuit, then, we can write –

$$H = I^2 Rt$$

The above formula is called the Joule's law of heating.

  - The law implies that heat produced in a resistor is (i) directly proportional to the square of current for a given resistance, (ii) directly proportional to resistance for a given current, and (iii) directly proportional to the time for which the current flows through the resistor.

Electric power

- The rate at which electric energy is dissipated or consumed in an electrical circuit is termed as electric power.

The power 'P' is given by –

$$P = VI$$

or, $P = I^2 R = V^2 / R$

- The S.I unit of electric power is Watt (W)

so, 1W = 1 Volt x 1 Ampere

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

1 kW h= 1000 watt × 3600 second = 3.6 × 106 watt second = 3.6 × 106 joule (J)

PYQs from 2014-2024

Two conducting wires A and B are made of same material. If the length of B is twice that of A and the radius of circular cross-section of A is twice that of B, then their resistances R_A and R_B are in the ratio

(a) 2 : 1

(b) 1 : 2

(c) 1 : 8

(d) 1 : 4

If the value of a fuse is 8A, then:

1. Fuse will start working only when the current is more than 8A.
2. The fuse will have a magnetic induction of more than 8.
3. The fuse will melt if the current exceeds 8A.
4. More than one of the above
5. None of the above

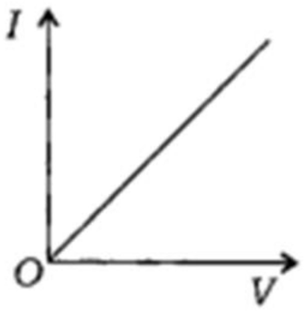
During short-circuiting, the current flowing in the electrical circuit

(a) reduces substantially

(b) does not change

(c) increases instantaneously

(d) varies continuously



The current (I)-voltage (V) plot of a certain electronic device is given above. The device is

(a) a semiconductor

(b) a conductor which obeys Ohm's law

(c) a superconductor

(d) an insulator

A fuse is used in an electric circuit to

(a) break the circuit when excessive current flows through the circuit

(b) break the circuit when power gets off

(c) indicate if the current is flowing uninterrupted

(d) complete the circuit for flow of current

The product of conductivity and resistivity of a conductor

(a) depends on pressure applied

(b) depends on current flowing through conductor

(c) is the same for all conductors

(d) varies from conductor to conductor

Which one of the following statements is correct with regard to the material of electrical insulators ?

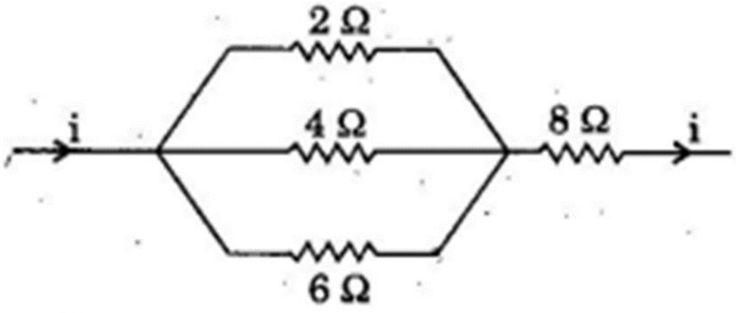
(a) They contain no electrons

(b) Electrons do not flow easily through them

(c) They are crystals

(d) They have more number of electrons than the protons on their surface

Consider the following circuit :



The equivalent resistance of the circuit will be

(a) 12 Ω

(b) $8\frac{11}{12}$ Ω

(c) $9\frac{1}{11}$ Ω

(d) $\frac{24}{25}$ Ω

A circular coil of single turn has a resistance of 20 Ω. Which one of the following is the correct value for the resistance between the ends of any diameter of the coil ?

(a) 5 Ω

(b) 10 Ω

(c) 20 Ω

(d) 40 Ω

Which one of the following is the value of 1 kWh of energy converted into joules ?

(a) $1 \cdot 8 \times 10^6$ J

(b) $3 \cdot 6 \times 10^6$ J

(c) $6 \cdot 0 \times 10^6$ J

(d) $7 \cdot 2 \times 10^6$ J

. Let us consider a copper wire having radius r and length l. Let its resistance be R. If the radius of another copper wire is $2r$ and the length is $l/2$ then the resistance of this wire will be

(a) R

(b) $2R$

(c) $R/4$

(d) $R/8$

The connecting cable of electrical appliances like electric iron, water heater or room heater contains three insulated copper wires of three different colours-red, green and black. Which one of the following is the correct colour code?

[2018-II]

Red-live wire, Green-neutral wire, Black-ground wire

Red-neutral wire, Green-ground wire, Black-live wire

Red-live wire, Green-ground wire, Black-neutral wire

Red-ground wire, Green-live wire, Black-neutral wire

Step-up transformers are used for

increasing electrical power

decreasing electrical power

decreasing voltage

increasing voltage

Which one of the following devices is non-ohmic? *[2018-I]*

Conducting copper coil

Electric heating coil

Semi conductor diode

Rheostat

A current of 1·0 A is drawn by a filament of an electric bulb for 10 minutes. The amount of electric charge that flows through the circuit is

(a) 0·1 C

(b) 10 C

(c) 600 C

(d) 800 C

Which one of the following formulas does ***not*** represent electrical power ?

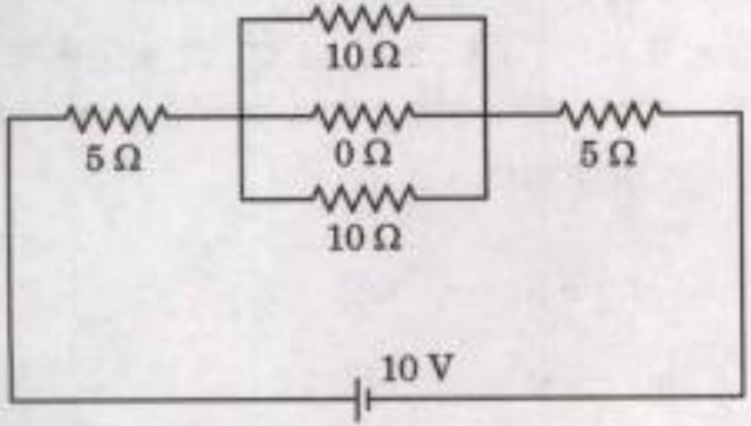
(a) $I^2 R$

(b) $I R^2$

(c) $V I$

(d) V^2 / R

. Consider the following electric circuit :



The current in the above electric circuit is :

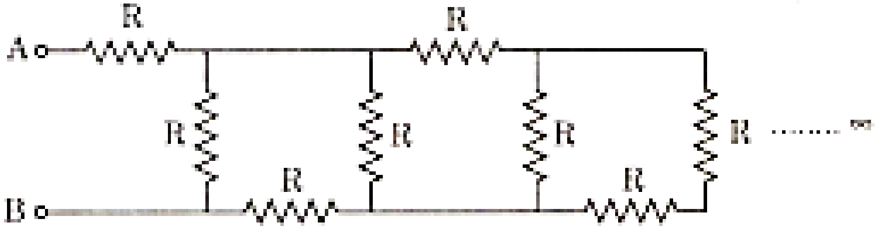
(a) 1 A

(b) (10/15) A

(c) 2 A

(d) 1·5 A

51. An infinite combination of resistors, each having resistance R = 4 Ω, is given below. What is the net resistance between the points A and B ? (Each resistance is of equal value, R = 4)



(a) 0 Ω

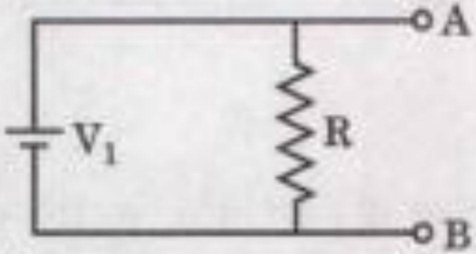
(b) $2 + 2\sqrt{5}$ Ω

(c) $2 + \sqrt{5}$ Ω

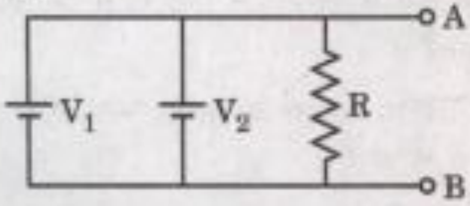
(d) ∞ Ω

An electric circuit is given below. $V_1 = 1$ V an

Resistance $R = 1000\ \Omega$.



The current through the resistance R is very close to 1 mA and the voltage across point A and B, $V_{AB} = 1$ V. Now the circuit is changed to :



where value of $V_2 = 5$ V. The internal resistances of both the batteries are $0 \cdot 1\ \Omega$. The current through the resistance R is about :

(a) 1·0 mA

(b) 1·2 mA

(c) 3·0 mA

(d) 5·0 mA

. If the current through an electrical machine running on direct current is 15 A and the machine runs for 10 minutes, the charge that passes through the machine during this time is :

(a) 1·50 C

(b) 150 C

(c) 900 C

(d) 9000 C

"The sum of emf's and potential differences around a closed loop equals zero" is a consequence of

Ohm's law.

Conservation of charge.

Conservation of momentum.

Conservation of energy.

Which one of the following statements regarding Ohm's law is ***not*** correct ?

(a) Ohm's law is an assumption that current through a conductor is always directly proportional to the potential difference applied to it.

(b) A conducting device obeys Ohm's law when the resistance of a device is independent of magnitude and polarity of applied potential difference.

(c) A conducting material obeys Ohm's law when the resistance of material is independent of the magnitude and direction of applied electric field.

(d) All homogeneous materials obey Ohm's law irrespective of whether the field is within range or strong.

"The sum of emf's and potential differences around a closed loop equals zero" is a consequence of

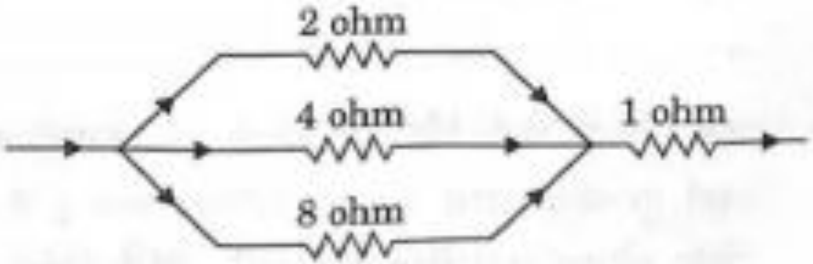
(a) Ohm's law.

(b) Conservation of charge.

(c) Conservation of momentum.

(d) Conservation of energy.

. Consider the following part of an electric circuit :



The total electrical resistance in the given part of the electric circuit is

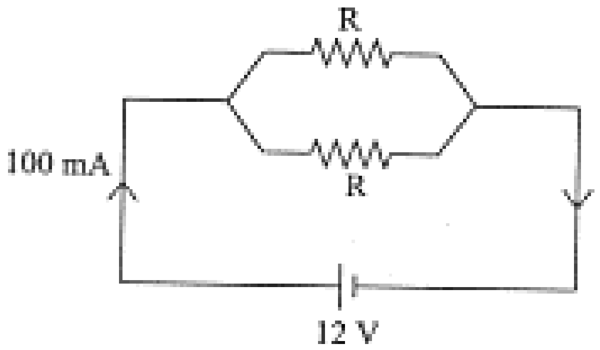
(a) $\frac{15}{8}$ ohm

(b) $\frac{15}{7}$ ohm

(c) 15 ohm

(d) $\frac{17}{3}$ ohm

2. Two equal resistors R are connected in parallel, and a battery of 12 V is connected across this combination. A dc current of 100 mA flows through the circuit as shown below :



The value of R is

(a) 120 Ω

(b) 240 Ω

(c) 60 Ω

(d) 100 Ω

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. A metallic wire having resistance of 20 Ω is cut into two equal parts in length. These parts are then connected in parallel. The resistance of this parallel combination is equal to

(a) 20 Ω

(b) 10 Ω

(c) 5 Ω

(d) 15 Ω

4. When the short circuit condition occurs, the current in the circuit

(a) becomes zero

(b) remains constant

(c) increases substantially

(d) keeps on changing randomly

Three equal resistors are connected in parallel configuration in a closed electrical circuit. Then the total resistance in the circuit becomes

one-third of the individual resistance.

two-third of the individual resistance.

equal to the individual resistance.

three times of the individual resistance.

If a free electron moves through a potential difference of 1 kV, then the energy gained by the electron is given by

(a) 1.6×10^{-19} J

(b) 1.6×10^{-16} J

(c) 1×10^{-19} J

(d) 1×10^{-16} J

Water is heated with a coil of resistance R connected to domestic supply. The rise of temperature of water will depend on

Supply voltage.

Current passing through the coil.

Time for which voltage is supplied.

Select the correct answer from among the following :

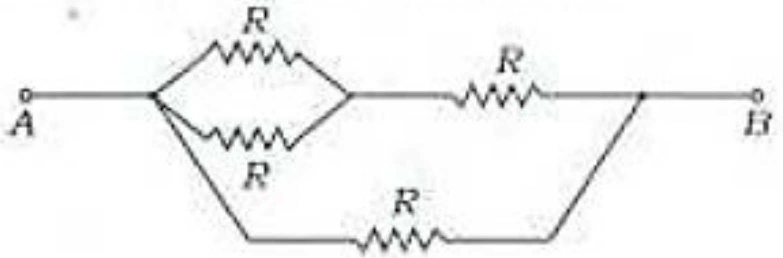
1, 2 and 3

1 and 2 only

1 only

2 and 3 only

Consider the following circuit :



Which one of the following is the value of the resistance between points A and B in the circuit given above?

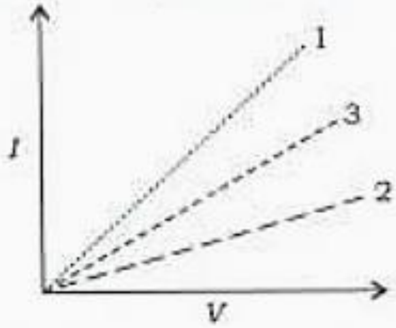
(a) $\frac{2}{5}R$

(b) $\frac{3}{5}R$

(c) $\frac{3}{2}R$

(d) $4R$

The graphs between current (I) and voltage (V) for three linear resistors 1, 2 and 3 are given below :



If R_1, R_2 and R_3 are the resistances of these resistors, then which one of the following is correct?

(a) $R_1 > R_2 > R_3$

(b) $R_1 < R_3 < R_2$

(c) $R_3 < R_1 < R_2$

(d) $R_3 > R_2 > R_1$

The instrument used for detecting the presence of electric current in a circuit is

Refractometer

Galvanometer

Viscometer

Diffractometer

In an electric circuit, a wire of resistance 10 Ω is used. If this wire is stretched to a length double of its original value, the current in the circuit would become :

(a) half of its original value.

(b) double of its original value.

(c) one-fourth of its original value.

(d) four times of its original value.

3)

An electric lamp of 100 watt is used for 10 hours per day. The 'units' of energy consumed in one day by the lamp is [NDA]

A)

○ 1 unit

B)

○ 0.1 unit

C)

○ 10 units

D)

○ 100 units

View Solution

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4)

The main power supply in India is at 220 V, whereas that in the US is at 110 V. Which one among the following statements in this regard is correct? [NDA]

A)

○ 110 V is safer but more expensive to maintain

B)

○ 110 V is safer and cheaper to maintain

C)

○ 110 V leads to lower power loss

D)

○ 110 V works better at higher latitudes

During short-circuiting, the current flowing in the electrical circuit [2014-I]

reduces substantially

does not change

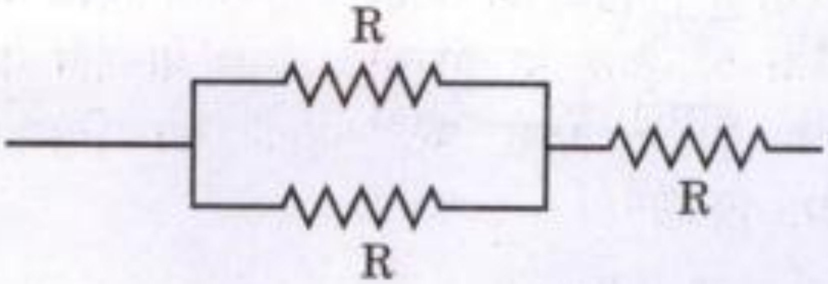
increases instantaneously

varies continuously

Which of the following is **NOT** based on the heating effect of current?

1. Electric heater
2. Electric bulb (with filament)
3. Electric iron
4. Microwave

What is the total resistance in the following circuit element ?



(a) R/2

(b) 3R

(c) 3R/2

(d) 2R/3

Which one of the following formulas does ***not*** represent electrical power ?

$I^2 R$

$I R^2$

$V I$

V^2 / R

Fuse wire used in electric instruments is made up of

1. Pure zinc
2. Pure lead
3. Alloy of lead and tin
4. More than one of the above
5. None of the above