

Electricity

Periodic Test

Q.1. Define resistivity.

Answer: The resistance offered by a conductor of unit length and unit cross section is known as resistivity.

Q.2. Out of the following bulbs rated 40 W, 220 V, 60 W, 220 V and 100 W, 220 V, which one will glow the brightest when connected in series to a supply of 220 V?

Answer: We know that,

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

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

Now, as all the bulbs are given the same voltage so resistance of the 40W bulb is the greatest.

As the bulbs are connected in series so the current through the bulbs are the same

$$P = I^2 R$$

So the power if the 40W bulb is the greatest and the power dissipated gives the glow of the bulb.

Q.3. State the factors that alter the resistance of a conductor. Write the mathematical expression.

Answer: The resistance (R) of a conductor of length l and area of cross section (A) is given by

$$R = \rho \left(\frac{l}{A} \right)$$

With the change in length and area of the conductor the resistance changes.

Q.4. State Joules law of heating and give its expression.

Answer: According to Joule's law of heating the heat produced in the resistor is

1. Directly proportional to the square of the current through the resistor
2. Directly proportional to the resistance of the given resistor

3. Directly proportional to the time for which the current flows.

Mathematically, Joule's law of heating is given by

$$H = i^2 R t$$

Q.5. Why the cord of a heating element does not glow while the heating element glows?

Answer: The glow of an element is due to the power dissipation of the element. The power of an element is given by

$$p = i^2 R$$

As the resistance of the heating element is higher than the cords, the power dissipation of the heating element is greater and it glows.

Q.6. What is the commercial unit of electrical energy? Convert it into joule. What is the other name of the commercial unit? What is meant by a parallel combination of resistors? Deduce an expression for the equivalent resistance when two resistors are connected in parallel.

Answer: Commercial unit of electrical energy is the unit in which all our household electrical consumptions are measured.

$$1 \text{ kWh} = 1000 \text{ watt} \times 3600 \text{ seconds}$$

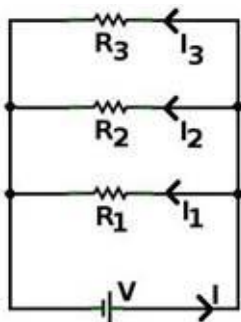
$$= 3.6 \times 10^6 \text{ J}$$

The commercial unit of current is kilowatt hour (kWh).

In parallel combination of resistors, the voltage across all the resistors are constant but the total current is divided in all the branches.

As the current is given by

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



So, in the circuit

$$i = i_1 + i_2 + i_3$$

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

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

Hence, in parallel connection the reciprocal of equivalent resistance is equal to the sum of reciprocal of individual resistances.

Q.7. Two resistors of 5 Ω and 10 Ω are connected in parallel. Eight such sets are connected in series.

Find the equivalent resistance of this combination.

Answer: Equivalent resistance of the parallel combination is

$$R_p = \frac{r_1 \times r_2}{r_1 + r_2}$$

$$= \frac{5 \times 10}{5 + 10}$$

$$= \frac{50}{15}$$

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

These eight resistances are connected in series, so

$$R = \frac{10}{3} + \frac{10}{3} + \frac{10}{3} + \dots + \frac{10}{3}$$

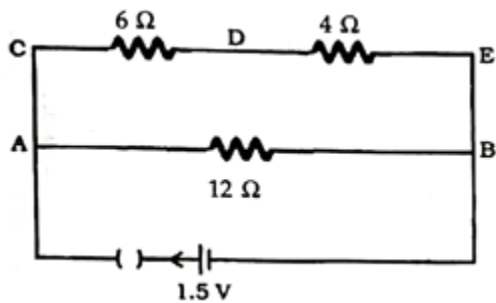
$$R = 8 \times \left(\frac{10}{3} \right)$$

$$R = \frac{80}{3} \Omega$$

So, the equivalent resistance of the combination is $\frac{80}{3} \Omega$

Q.8. In the circuit shown in figure, calculate

- (i) the current through the arms AB, AC and CDE,
(ii) the potential difference across AB, CD and DE.



Answer: The equivalent resistance of the series combination is

$$R_s = r_1 + r_2$$

$$= 6 + 4$$

$$= 10 \, \Omega$$

The equivalent resistance of the parallel combination and hence circuit is given by,

$$R_p \text{ or } R = \frac{r_3 \times R_s}{r_3 + R_s}$$

$$R = \frac{12 \times 10}{12 + 10}$$

$$R = \frac{120}{22} = 5.45 \, \Omega$$

If the key in the circuit is closed then only the current will flow

Total current is given by

$$i = \frac{1.5}{5.45} = 0.275 \, A$$

(i) As the circuit is in parallel combination, the current gets divided into the branches in ratio with the resistances

So the current in the branch AB is

$$i_{AB} = \frac{6 + 4}{(12 + 6 + 4)} \times 0.275$$

$$i_{AB} = \frac{10}{22} \times 0.275$$

$$i_{AB} = 0.125 \text{ A}$$

The current in the branch AC and CDE are same as they are in parallel

$$i_{AC} = \frac{12}{12 + 4 + 6} \times 0.275$$

$$i_{AC} = \frac{12}{22} \times 0.275$$

$$i_{AC} = 0.15 \text{ A}$$

(ii). As the circuit is in parallel connection the potential difference across AB and CE are the same

$$V_{AB} = 1.5 \text{ V}$$

Now the potential difference across CD and CE is proportional to the resistances, so

$$V_{CD} = \frac{6}{6 + 4} \times 1.5$$

$$V_{CD} = \frac{6}{10} \times 1.5$$

$$V_{CD} = 0.9 \text{ V}$$

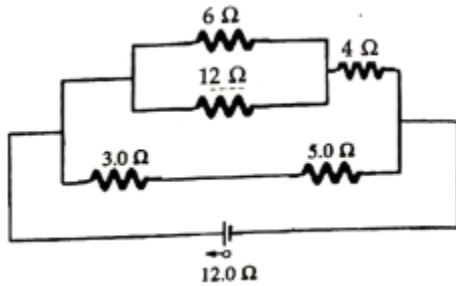
And,

$$V_{CE} = \frac{4}{6 + 4} \times 1.5$$

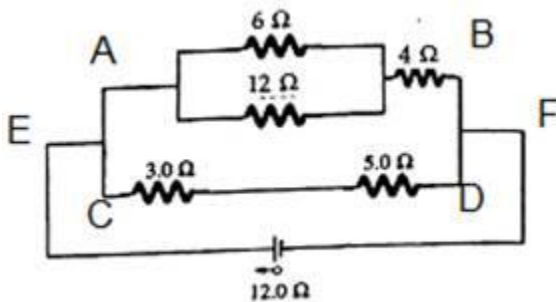
$$V_{CE} = \frac{4}{10} \times 1.5$$

$$V_{CE} = 0.6 \text{ V}$$

Q.9. Find the equivalent resistance of the following combination of resistors:



Answer:



The resistance across AB is given by,

$$R_{AB} = 4 + \frac{12 \times 4}{12 + 4}$$

$$R_{AB} = 4 + 4$$

$$R_{AB} = 8 \Omega$$

The resistance across CD is $(3+5) \Omega$

$$R_{CD} = 3 + 5 = 8 \Omega$$

The resistance across EF is $R_{EF} = \frac{R_{AB} \times R_{CD}}{R_{AB} + R_{CD}}$

$$R_{EF} = \frac{8 \times 8}{8 + 8} = 4 \Omega$$

Now, the internal resistance of the cell is in series with R_{EF}

$$R_{eq} = 4 + 12 = 16 \Omega$$

Q. 10. (a) Express ohm's law by a mathematical formula.

(b) Draw a circuit diagram to verify ohm's law.

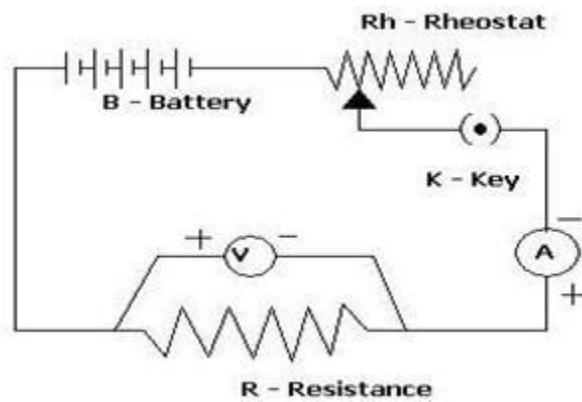
(c) Present the relationship between the voltage applied across a conductor and the current flowing through it graphically.

Answer: (a) Mathematically, Ohm's law is given by

$$V = IR$$

Where v is the potential difference, I is the current and R is the resistance

(b)



This circuit diagram explains Ohm's Law.

(c) The potential difference across a conductor is proportional to the current through the resistor.

$$V \propto I$$

$$V = IR$$

This is similar to the equation of a straight line passing through the origin.

So the graph between voltage and current is a straight line with a slope of R .

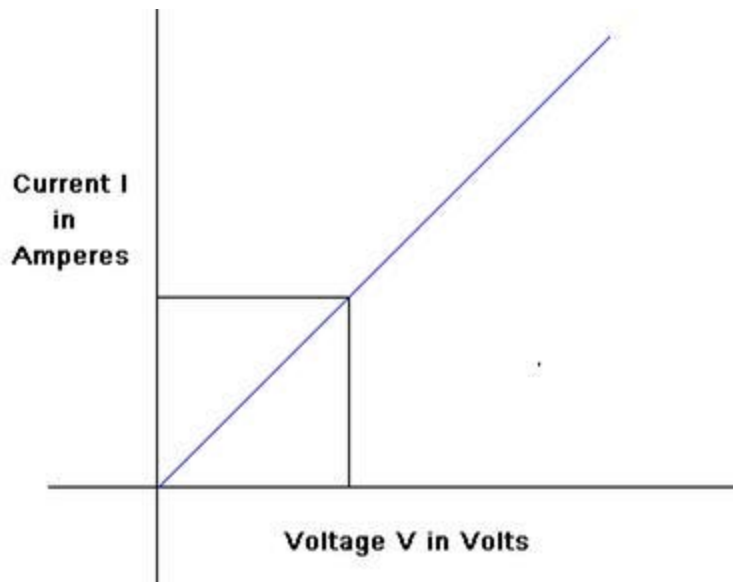


Fig. Graph of I vs V

Comprehensive Exercises (MCQ)

Q. 1 No current flows between two charged bodies when connected, if they have the same:

- A. capacity
- B. quantity of charge
- C. charge to potential ratio
- D. potential

Answer: According to Ohm's Law current only flows when there is a potential difference, if the potential difference is zero then no current will flow.

Q. 2 If a wire of resistance R is melted and recast to half of its length, then new resistance of the wire will be:

- A. $R/4$
- B. $R/2$
- C. R
- D. $2R$

Answer: As the volume of the wire remains same

$$A_1 l_1 = A_2 l_2$$

$$A_1 l = A_2 \left(\frac{l}{2} \right)$$

$$A_1 = \frac{A_2}{2}$$

Now,

$$R_1 = R = \rho \left(\frac{l_1}{A_1} \right)$$

$$R_2 = \rho \left(\frac{l_2}{A_2} \right) = \frac{\rho \left(\frac{l_1}{2} \right)}{2A_1} = \frac{1}{4} \times \rho \left(\frac{l_1}{A_1} \right) = \frac{1}{4} R_1 = \frac{R}{4}$$

Q.3. An equal resistor are first connected in series and then connected in parallel. The ratio of the maximum to the minimum resistance is:

A. n

B. 1/n

C. n²

D. 1/n²

Answer: The maximum resistance is obtained in case of series resistance (R_s) and the minimum resistance is obtained in case of parallel resistance (R_p)

If the resistance of each wire is R, then

$$R_s = n \times R$$

$$R_p = \frac{R}{n}$$

Therefore,

$$\frac{R_s}{R_p} = \frac{nR}{\frac{R}{n}} = n^2$$

Q.4. If R_1 and R_2 are the resistances of filaments of a 400 W and a 200 W lamp, designed to operate on the same voltage, then:

A. $R_1 = 2R_2$

B. $R_2 = 2R_1$

C. $R_2 = 4R_1$

D. $R_1 = R_2$

Answer: We know that,

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

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

Hence,

$$\frac{R_1}{R_2} = \frac{P_2}{P_1}$$

$$\frac{R_1}{R_2} = \frac{200}{400}$$

$$R_2 = 2R_1$$

Q.5. In a circuit containing two unequal resistors connected in parallel:

A. the current is same in both the resistors.

B. the current is large in the larger resistance.

C. the voltage is same across both the resistors.

D. the voltage drop is larger across the larger resistance.

Answer: In parallel connection the voltage is equal in the branches

Q.6. The equivalent resistance in series combination is:

A. smaller than the largest resistance.

B. larger than the largest resistance

C. smaller than the smallest resistance

D. larger than the smallest resistance.

Answer: As the equivalent resistance in series connection is the sum of the individual resistances, so it is greater than the largest resistance.

Q.7. A house is fitted with 5 tubes each of 40 W. If all the tubes are lighted for 20 hours and if the cost of electrical unit is Rs. 0.50, the total cost of electricity consumed is:

A. Rs. 20

B. Rs. 4

C. Rs. 5

D. Rs. 2

Answer: The electrical power of a single tube in kilowatt = $\frac{40}{1000} = 0.040 \text{ kW}$

The electrical power of 5 tubes in kilowatt = 0.2 kW

Total unit of power consumed = $0.2 \times 20 = 4 \text{ kWh} = 4 \text{ units}$

The cost of electricity consumed = $4 \times 0.50 = \text{Rs. } 2$

Q. 8 Of the two bulbs in a house, one glows brighter than the other. Which of the two has a larger resistance?

A. the dim bulb

B. the brighter bulb

C. both have the same resistance

D. becomes four times

Answer: The brightness of a bulb is representation of the power dissipated by the bulb.

The power is given by

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

So, the dimmer bulb has larger resistance.

Q.9. You are given a resistance wire of length 50 cm and a battery of negligible resistance. In which of the following cases is the largest amount of heat generated:

- A. when only half of the wire is connected to the battery.**
- B. when the wire is divided into four equal parts and all the four parts are connected in parallel.**
- C. when the wire is divided into two equal parts and both the parts are connected in parallel.**
- D. when the wire is connected to the battery directly.**

Answer: Heat generated in an element is given by

$$H = \frac{V^2}{R} t$$

For largest amount of heat generation, R must be smallest and R is smallest in parallel connection.

Q.10. You are given three bulbs of 25 W, 40 W and 60 W marked at 220 V. Which one of them has lowest resistance?

- A. 60 W bulb**
- B. 40 W bulb**
- C. 25 W bulb**
- D. no conclusion can be drawn**

Answer: The power of a bulb is given by

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

Hence, the resistance will be minimum if the power is maximum. So, 60W bulb will have largest resistance.

Q.11. The potential difference across a conductor is doubled, the rate of generation of heat will:

- A. become one-fourth**
- B. be halved**
- C. be doubled**
- D. becomes four times**

Answer: Heat generated is given by,

$$H = \frac{V^2}{R}t$$

$$H \propto V^2$$

Hence, with doubling of the potential difference, the heat produced will be four times.

Q.12. What are the essential requirements of a heater filament?

- A. high resistivity, low melting point**
- B. low resistivity, low melting point**
- C. high resistivity, high melting point**
- D. low resistivity, high melting point.**

Answer: According to joule's law of heating,

$$H = i^2 R t$$

So, greater the resistance (i.e. greater resistivity), greater the heat produced.

To bear the amount of heat produced, the melting point of the element must be high.

Q.13. Two wires of the same metal have the same length, but cross-sections are in the ratio 3:1. They are joined in series. The resistance of the thicker wire is 10 Ω . The total resistance of the combination will be:

- A. 40 Ω**
- B. 40/3 Ω**

C. $5/2 \Omega$

D. 100Ω .

Answer: As the length of the wires are the same so the resistances will depend only upon the cross-sectional area.

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

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

So,

$$\frac{R_1}{R_2} = \frac{A_2}{A_1}$$

$$\frac{R_1}{R_2} = \frac{1}{3}$$

$$R_2 = 3R_1 = 3 \times 10 = 30 \Omega$$

So, the resistance of the combination =

$$R_1 + R_2 = 10 + 30 = 40 \Omega$$

Q.14. You are given three equal resistors. The number of resistances which can be obtained by joining them in series and in parallel grouping is:

A. two

B. three

C. four

D. six

Answer: The numbers of combinations are:

1. All three in parallel

2. All three in series

3. Two in parallel and one in series
4. Two in series and one in parallel

Comprehensive Exercises (T/F)

Q.1. Write true or false for the following statements:

The unit of measurement of charge is coulomb.

Answer: True

Charge is measured in coulomb.

Q.2. Write true or false for the following statements:

A metal has a very large number of free electrons and a non-metal very less number of free electrons.

Answer: True

Q.3. Write true or false for the following statements:

An electron in a metal is free to move anywhere but cannot leave the metal.

Answer: True

Due to attraction of the atoms, the free electrons cannot leave the metal.

Q.4. Write true or false for the following statements:

Potential and potential difference are vector quantities.

Answer: False

Potential and potential difference are scalar quantities.

Q.5. Write true or false for the following statements:

Potential is positive of positively charged body and is negative of a negatively charged body.

Answer: True

As potential depends on the charge of a body, potential is positive of positively charged body and is negative of a negatively charged body.

Q.6. Write true or false for the following statements:

Positive charges flow from high potential to low potential.

Answer: True

Q.7, Write true or false for the following statements:

Battery is a source of maintaining a constant potential difference across two ends of a conductor.

Answer: True

Q.8. Write true or false for the following statements:

The units of resistance are ampere.

Answer: False

The units of resistance is ohm (Ω).

Q.9. Write true or false for the following statements:

If the resistance of a conductor is doubled, the current is halved.

Answer: True

This is in accordance with ohm's law.

Q.10. Write true or false for the following statements:

Resistance of a conductor increases with the increase in temperature.

Answer: True

With increase in temperature the random motion of the atoms and electrons in a conductor increases and so the resistance decreases.

Q.11 Write true or false for the following statements:

Insulator like wood and rubber has a very low electrical resistance.

Answer: False

Insulator like wood and rubber has a very high electrical resistance.

Q.12. Write true or false for the following statements:

If resistors are connected in series, the current through each resistor remains the same.

Answer: True

In series connection the current through the resistance is the same.

Q.13. Write true or false for the following statements:

If resistors are connected in parallel, the voltage across each remains the same.

Answer: True

In parallel connection the voltage across the resistance is the same.

Q.14. Write true or false for the following statements:

Resistance of a piece of rubber is more than that of a piece of copper.

Answer: True

Because rubber is an insulator while copper is a conductor.

Q.15. Write true or false for the following statements:

Electric power of a circuit is the rate at which work is done in maintaining the electric current in the circuit.

Answer: True

Q.16. Write true or false for the following statements:

1 kWh = 3.6×10^6 joule

Answer: True

1kWh = 1000watts × 3600 seconds

= 3.6×10^6 J

Q.17. Write true or false for the following statements:

Electric power is also called BOTU.

Answer: False

BOTU measures electrical energy.

Q.18. Write true or false for the following statements:

Heat dissipated by a conductor when a current is passed through it is directly proportional to the resistance of the conductor.

Answer: True

According to joule's law of heating,

$$H = i^2 R t$$

Q.19. Write true or false for the following statements:

Electric bulb works on heating effect of current.

Answer: True

Q.20. Write true or false for the following statements:

The electrical appliance having higher power draws a larger current.

Answer: True

Power is given by,

Q.21. Write true or false for the following statements:

The quantity of charge flowing past a point multiplied by time is current.

Answer: False

Current is the amount of charge flowing per unit time.

$$i = \frac{q}{t}$$

Q. 22. Write true or false for the following statements:

The flow of charge through a conducting wire connected to a cell is the result of chemical reaction inside the cell.

Answer: True

Q. 23. Write true or false for the following statements:

The resistivity of all pure metals increases with increase in temperature.

Answer: True

With increase in temperature the random motion of the atoms and electrons in a conductor increases and so the resistance decreases.

Q. 24. Write true or false for the following statements:

Ohm's law is a relation between the power used in a circuit to the current and the potential difference.

Answer: False

According to ohm's law,

$$V=IR$$

Q. 25. Write true or false for the following statements:

A series circuit has only one conducting path for the electrons that move through it; a parallel circuit has multiple conducting paths.

Answer: True

As in parallel connection there are multiple branches so multiple conducting paths.

Q.26. Write true or false for the following statements:

A conducting wire offers resistance to the flow of electrons because electrons repel each other in the wire.

Answer: False

A conducting wire offers resistance to the flow of electrons due to the random collision between the electrons and the stationary atoms.