Current Electricity

EXERCISE

11.0 : Introduction

Q.1. Define electric current. State its SI unit.

Ans: Electric current:

i. The rate of flow of electric charge through any cross-section of the conducting wire in the electrical circuit is called electric current.

ii. Magnitude of electric current, $I = \frac{q}{t}$

where, q = quantity of charge and
t = time of flow.

iii. Current is a scalar quantity.

iv. The SI unit of current is ampere.

From relation $I = \frac{q}{t}$,

if q = 1 coulomb and t = 1 second, then
1 =1 ampere
Hence, one ampere is that current which is produced in the circuit, when one coulomb of charge flows for one second through any cross section of the conductor.

Q.2. When a current is passed through a conductor, will it be charged?

Ans: No, when a current is passed through a conductor, it will not be charged. For conduction in a conductor, the charge carriers are not excess charge carriers. The number of free charge carriers is equal to the number of opposite charge on the nearly stationary ions of the material. Hence, the net charge is zero whether or not current is passed through the conductor.

Q.3. In a picture tube of T.V., electrons move from rear to the front. What is the direction of the current?

Ans: The direction of current (conventional) is from the front ofthe picture tube to rear. This is because, the' direction of conventional current is opposite to the direction of electron flow.

11.1 : Ohm's law :

Q.4. State and explain Ohm's law.

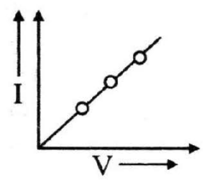
Ans: Statement: As long as the physical state (material, dimensions, temperature etc.) of a conductor remains the same, the electric current flowing through a given conductor is directly proportional to the potential difference applied across it.

Explanation:

i. Let I = magnitude of current passing through the conductor
V = potential difference
According to Ohm's law,
$I \propto V$ or $V \propto I$
$\therefore$ V = RI
where, R is a constant of proportionality called resistance of the conductor.

ii. Mathematically, $R = \frac{V}{I}$

iii. If I versus V graph is plotted, then the slope of graph is a straight line as shown in figure.



Q.5. Define resistance of a conductor. State its S.I. unit and dimensions.

Ans: Resistance of a conductor:

i. Resistance of a conductor is the opposition to flow of current in the electric circuit.
It is numerically equal to the ratio of potential difference across the conductor to resulting current applied through it.

ii. The SI unit of resistance is ohm. It is denoted by Ω.
In the formula,

$R = \frac{V}{I}$ if V = 1 volt I = 1 ampere then,

$R = 1\ \Omega$.
Thus, the resistance of a conductor is said to be one ohm if a current of one ampere passes through it, when a P.D. of one volt is maintained between its terminals.

iii. Dimensions of R are $[M^1L^2T^{-3}A^{-2}]$

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

We know that, $V = \frac{W}{q}$

$$R = \frac{W}{Iq} = \frac{\left[M^1L^2T^{-2}\right]}{[A][TA]} = [M^1L^2T^{-3}A^{-2}]$$

Q.6. Define conductance. Write down its units and dimensions.

Ans: Conductance:

i. The reciprocal of resistance is called conductance.
It is given by,

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

ii. Unit: SI unit is Siemens (S) or mho (Ω^{-1})

iii. Dimensions: $[M^{-1}L^{-2}T^3A^2]$

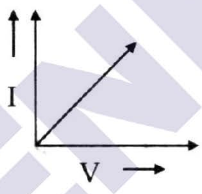
$\because$ Conductance, $G = \frac{1}{R}$

Therefore, its dimensions are given as $[M^{-1}L^{-2}T^3A^2]$

Q.7. Define ohmic materials and non-ohmic materials with examples.

Ans: i. Ohmic materials:

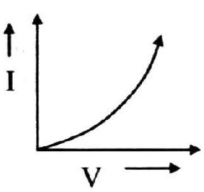
Material which obeys ohm's law are called ohmic materials.



For such material, I versus V graph is a straight line.
For e.g., Gold, Silver, Copper, etc.

ii. Non-ohmic materials:

Those materials which do not obey ohm's law are called non-ohmic or non-linear materials.



For such material I versus V graph is a curve line.
For e.g., Thermistors, semiconductors diodes, etc.

Q.8. State and explain limitations of Ohm's law.

Ans: a. Potential difference may vary nonlinearly with current.

i. According to Ohm's law, potential difference across a metallic conductor varies linearly with current.

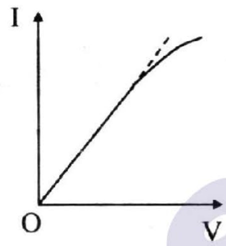


Figure (a) I –V curve for good conductor

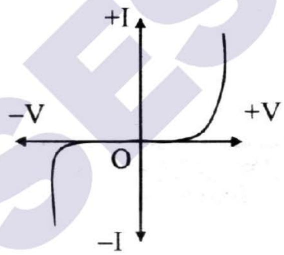


Figure (b) I–V curve for semiconductor diode

ii. Figure (a) shows I – V curve for good conductor. The dotted line represents ideal Ohm's law and solid line represents actual observation.

iii. The diversion from ideal curve is due to heating effect of current. When the current increases, temperature of conductor increases.

iv. As a result of this, resistance of conductor increases. Hence, slight decrease in current due to increase in resistance is actually observed.

v. Metals obey Ohm's law only if their physical condition, such as temperature, remains constant. Their resistance changes with temperature. Hence, their I – V characteristics deviates from a straight line if the temperature increases.

b. The variation of current with potential difference may depend upon sign of the potential difference applied.

i. For semi-conductor devices, electrolytes, this relation is not linear, but it may depend upon polarity of applied potential difference.

ii. Such conductors are called nonohmic materials. figure (b) shows I–V curves for semi-conductor diode.

iii. In figure (b), it is seen that variation of current with potential difference is non-linear so also magnitude of variation depends upon the sign of potential difference applied across it.

iv. While applying relation, R = V/I to non-ohmic materials, the value of current has to be considered, as R changes with I.

v. Such materials are used to rectify or amplify the current in the circuit.

Q.9. When external electric potential difference is applied across the conductor, electrons flow in the direction opposite to the current. Whether the number of free electrons in the conductor increase?

Ans: The number of free electrons in the conductor will not increase. When an external electric potential difference is applied across a metallic conductor, free electrons move through it from lower to higher potential end of the conductor. Electrons are injected into the conductor at its lower potential end and an equal number of electrons are extracted at the higher potential end. So the number of free electrons in the conductor remains the same.

Q.10. Answer the following questions:

A. A steady current flows in a metallic conductor of non-uniform crosssection. Explain which of these quantities is constant along the conductor : current, current density, electric field and drift speed?

B. Is Ohm's law universally applicable for all conducting elements? If not, give examples of elements which do not obey Ohm's law.

C. A low voltage supply from which one needs high currents must have low internal resistance. Why?

D. A high tension (HT) supply of say 6 kV must have a very large internal resistance. Why? (NCERT)

Ans: A. Among all the quantities given in the question, current is the only quantity that will remain constant because it is independent of the area of cross-section.

B. Ohm's law is not applicable to those conducting elements which do not obey Ohm's law (i.e. non-ohmic elements). For e.g., vacuum tubes, semi-conducting diode, liquid electrolyte etc.

C. The correct form of Ohm's law is,

$I = \frac{E}{R + r}$ where Rand r are the external and the internal resistances respectively. Now, for I to be maximum for a given R, the value of r must be the least.

D. A high tension (HT) supply must have a large internal resistance. Otherwise, if there is a short circuit by accident, then the current drawn will exceed the safety limit and will damage the circuit.

11.2 : Resistance and drift velocity :

Q.11. Explain the concept of resistance in a conductor.

Ans: Concept of resistance:

i. Atoms inside the conductor are in the state of vibration due to thermal agitation.

ii. When a potential difference is applied across a conductor, an electric field is set up inside the conductor and electron move in a direction opposite to the applied electric field.

iii. During the motion of electrons, they collide with the vibrating atoms of the conductor.

iv. These collisions of electrons against the vibrating atoms produce opposition to the flow of electrons. This opposition is called the resistance of the conductor.

v. Greater the number of collisions greater is the resistance of conductor.

vi. In the conductor, amplitude of vibration goes on increasing with increase in temperature. Hence, resistance of conductor increases with increase In temperature.

Q.12. Explain the concept of drift velocity.

Ans: i. In a metallic conductor, at room temperature electrons are in a state of random motion and frequently collide with atoms with the velocity of the order of 10^5 m/s. This motion is distributed in all the directions and there is no net transport of charge across any section of the conductor.

ii. When a potential difference is applied across conductor, electrons gain velocity in the direction opposite to the electric field.

iii. Between two successive collisions, an electron thus acquires a velocity component in the direction opposite to the field. This is in addition to its thermal velocity.

iv. As a result there is a definite drift of all the electrons. This drift velocity is superimposed on the random motion of the free electron and is very small, of the order of 10^{-3} m/s.

v. Due to drift velocity there is a net flow of electrons, i.e, there is an electron current opposite to the field.

vi. Thus, before setting up an electric field in the conductor, the average velocity of the electron is zero and so there is no net transport of charge in any direction.

vii. There is no current flow in the conductor. But after setting up an electric field, the electrons acquire a small drift velocity in a direction opposite to that of the field.

viii. There is net transport of charge and electric current flows through the conductor. Even though, the drift velocity is very small, the current can be very large because of the large number of electrons, all of which start drifting immediately after the field is applied.

11.3 : Specific resistance (resistivity)

Q.13. Explain the factors affecting resistance of a conductor.

Ans: Factors affecting resistance of a conductor:

i. Length of conductor: Resistance of conductor increases with increase in length i.e. $R \propto l$

$$\therefore \quad \frac{R_1}{R_2} = \frac{l_1}{l_2}$$

ii. Area of cross-section: Resistance of conductor decreases with increase in area of cross section i.e. $R \propto \frac{1}{A}$

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

iii. Nature of material: Some materials like silver, gold, copper etc have large number of free electrons, so they have less resistance. On the other hand materials like wood, rubber, etc, do not have large number of free electrons, so they have very low resistance.

Q.14. What is specific resistance? State its unit and dimensions. Discuss the factors on which specific resistance (resistivity) depends.

Ans: Specific resistance:

i. At constant temperature, the resistance (R) of a metallic conductor is directly proportional to its length (l) and inversely proportional to the area of cross section (A).

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

where ρ is a constant, called the specific resistance or resistivity of the material of the conductor.

$$\therefore \quad \rho = \frac{RA}{l}$$

ii. If $A = 1\ m^2$ and $l = 1$ m, $R = 1\,\Omega$ then $\rho = 1\ \Omega m$.

Thus, resistivity of material is the resistance of wire of unit length and unit area of cross section.

iii. Unit: Om in S.1. system.

iv. Dimensions: $[M^1L^3T^{-3}A^{-2}]$

v. The specific resistance depends upon the material and temperature of the conductor. It does not depend upon its physical dimensions.

Q.15. Define conductivity of a material. Write down its unit and dimensions.

Ans: Conductivity:

i. Reciprocal of resistivity is called conductivity.
It is denoted by σ or k.

$$\sigma = \frac{1}{\rho}$$

ii. Material having large resistivity are poor conductors or good insulators. Conversely, materials having small resistivity are good conductors.

iii. Unit: siemens/metre in S.1. system

iv. Dimensions: $[M^{-1}L^{-3}T^3A^2]$

Q.16. Define.

i. Conductors

ii. Insulators

iii. Semiconductors

Ans: i. Conductors: Those materials whose resistivity is negligibly small are called conductors.
For e.g., silver, copper, aluminium.

ii. **Insulators:** Those materials whose resistivity is very high are called insulators. For e.g., glass, rubber etc.

iii. **Semiconductors:** Those materials whose resistivity lies between that of conductors and insulatorsare calledsemiconductors. For e.g., silicon, germanium etc.

11.4 : Temperature dependence of resistance :

Q.17. A. Deflne temperature coefficient of resistance.

B. Derive an expression for it.

Ans: A. Temperature coefficient of resistance:

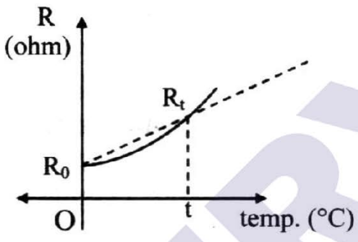
i. The temperature coefficient of resistance is defined as the increase in resistance per unit original resistance at 0° C (reference temperature) per degree rise in temperature.

$$\alpha = \frac{R_t - R_0}{R_0 t} = \frac{1}{R_0}\left[\frac{dR}{dt}\right],$$

ii. Unit of a is $°C^{-1}$

B. Expression for temperature coefficient:

i. Let R_0 be the resistance of a conductor at 0 °C and let R_t be its resistance when it is heated to t °C.



Resistance of metallic conductor versus temperature

ii. Thus, increase in resistance
$= R_t - R_0$
difference in temperature
$= (t - 0) = t$

iii. It is found that,
$(R_t - R_0) \propto R_0$ (initial resistance) ....(1)
$(R_t - R_0) \propto t$ (temperature difference) .... (2)
Combining equation (1) and (2),
$R_t - R_0 \propto R_0 t$ or, $R_t - R_0 = \alpha R_0 t$
where α is a constant called temperature coefficient of resistance.

$$\therefore \quad \alpha = \frac{R_t - R_0}{R_0 t} \quad ....(3)$$

From equation (3),
Resistance of a conductor at a particular temperature is $R_t = R_0(1 + \alpha t)$

Q.18. Explain the variation of resistivity of material with temperature.

Ans: Variation of resistivity with temperature:

i. The resistivity of a metal conductor increases with temperature. They have positive temperature coefficient (pTC). The graph of resistivity versus temperature is almost linear at high temperature but non-linear at low temperature as shown in figure (a).

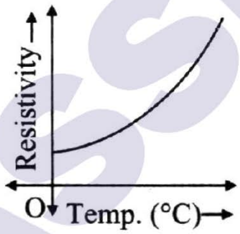


Figure (a)

ii. Alloys like nichrome and manganin have large resistivity but very small temperature coefficient of resistance. Hence, their resistivity versus temperature graph is a straight line with very small slope as shown in figure. (b).

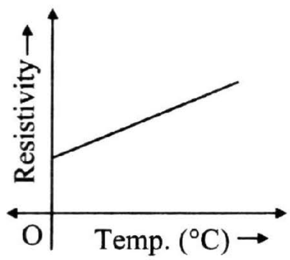


Figure (b)

iii. Semiconductors have negative temperature coefficient of resistance (NTC). Resistivity of semiconductors decreases with increase in temperature as shown in figure (c).

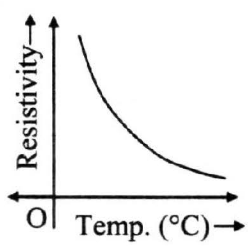


Figure (c)

Q.19. Explain effect of temperature on resistance

Ans: A. Temperature coefficient of resistance:

i. The temperature coefficient of resistance is defined as the increase in resistance per unit original resistance at 0° C (reference temperature) per degree rise in temperature.

$$\alpha = \frac{R_t - R_0}{R_0 t} = \frac{1}{R_0}\left[\frac{dR}{dt}\right],$$

ii. Unit of a is $°C^{-1}$

B. Expression for temperature coefficient:

i. Let R_0 be the resistance of a conductor at 0 °C and let R_t be its resistance when it is heated to t °C.

ii. Thus, increase in resistance
$= R_t - R_0$
difference in temperature
$= (t - 0) = t$

iii. It is found that,
$(R_t - R_0) \propto R_0$ (initial resistance) ....(1)
$(R_t - R_0) \propto t$ (temperature difference) .... (2)
Combining equation (1) and (2),
$R_t - R_0 \propto R_0 t$ or, $R_t - R_0 = \alpha\ R_0 t$
where α is a constant called temperature coefficient of resistance.

$$\therefore \quad \alpha = \frac{R_t - R_0}{R_0 t} \quad ....(3)$$

From equation (3),
Resistance of a conductor at a particular temperature is $R_t = R_0 (1 + \alpha t)$

Variation of resistivity with temperature:

i. The resistivity of a metal conductor increases with temperature. They have positive temperature coefficient (pTC). The graph of resistivity versus temperature is almost linear at high temperature but non-linear at low temperature as shown in figure (a).

ii. Alloys like nichrome and manganin have large resistivity but very small temperature coefficient of resistance. Hence, their resistivity versus temperature graph is a straight line with very small slope as shown in figure. (b).

iii. Semiconductors have negative temperature coefficient of resistance (NTC). Resistivity of semiconductors decreases with increase in temperature as shown in figure (c).

Q.20. Why is manganin used in production of high precision resistance?

Ans: i. Manganin is an alloy which has very small temperature coefficient of resistance.

ii. Resistance of such material does not change for small change in temperature.

iii. Hence, manganin is used in production of high precision resistance.

Q.21. What is thermistor? Explain.

Ans: Thermistor:

i. A thermally sensitive resistor, is called thermistor.

ii. It is a semiconductor device symbolically represented by.

iii. As it is thermally sensitive, a small change in its temperature causes a large change in its resistance. For this reason, thermistor is also called as thermal resistor.

iv. Thermistors may have positive temperature coefficient (PTC) or negative temperature coefficient (NTC).

Q.22. State the main applications of thermistors.

Ans: Applications of thermistors:

i. Thermistors are used in digital thermometers.

ii. They are used in automatic temperature control systems.

iii. They are used in remote temperature sensing.

iv. They are used in voltage stabilisation.

v. They are used to measure varying resistance.

vi. They are used to protect the windings of transformers, generators and motors.

vii. They are .used to protect electronic equipments from the high current.

Q.23. Explain the process of manufacturing thermistor.

Ans: i. Thermistors are manufactured by embedding the oxides of Mn, Fe, Co and Ni in ceramic binders.

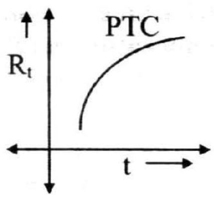
ii. These oxides are mixed in a suitable proportion and grind into fine powder.

iii. They are then compressed, so as to get the desired shape and heated to high temperature which forms the ceramic body of the thermistor.

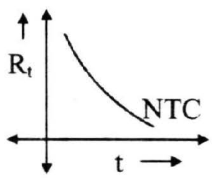
iv. They are in the form of beads, discs or rods.
v. Leads are provided to make electrical connection.

Q.24. What are PTC and NTC thermistors?

Ans: i. PTC thermistor:
Materials whose resistance increases non - linearly with increase in temperature are called positive temperature coefficient (PTC) thermistors.
For e.g., Pure metals



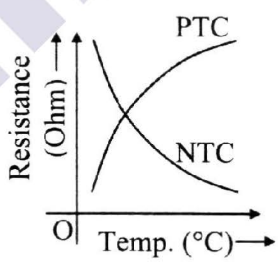
ii. NTC thermistor:
Materials whose resistance decreases non linearly with increase in temperature are called negative temperature coefficient (NTC) thermistors.
For e.g., Semiconductors like C, Si, etc.



Q.25. Explain the variation in resistance of a thermistor with temperature.

Ans: i. The resistance of PTC thermistors increases non-linearly with temperature and resistance of NTC thermistors decreases non-linearly with temperature as shown in figure.

ii. Thermistors resistance ranges from 0.1 Ω to 10k Ω and have temperature range of – 100 °C to 1100 °C.



Variation in resistance of thermistor with temperature

Q.26. A. What is superconductor?
B. State its properties.

Ans: Superconductor: Material which offer zero resistance at a certain temperature is called superconductor.
For e.g., Mercury at 4.2 K,

B. Properties:
i. Superconductor exhibits persistent current, i.e., once set up, a current continues to flow for a long time.
ii. It does not allow a magnetic field to penetrate its interior.
iii. Its coefficient of friction is almost half the value at non-super conducting state.

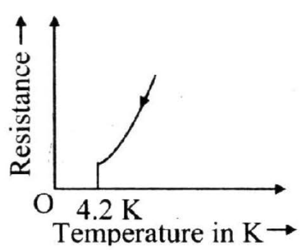
Q.27. What is superconductivity? State its applications.

Ans: Superconductivity: The phenomenon of losing resistivity completely at a particular low temperature is called superconductivity.

Applications of superconductivity:
i. Superconducting cables are used for power distribution without loss.
ii. Superconducting wires are used to increase speed of computers.
iii. They are used to produce very strong magnetic field without power loss just by setting large current in superconducting coils.
iv. Infrared sensor.
v. Magnetic separator.

Q.28. Write a short note on superconductivity.

Ans: i. Superconductivity was first discovered by Kamerlingh Onnes from Netherland in 1911. He showed that the resistivity of mercury completely disappeared, when its temperature was about 4.2 K (–269 °C). This dissapearance of resistance of some substance, at temperature very near to absolute zero, is called Superconductivity and such substances are known as superconductors.



ii. The graph of resistance against temperature (in K) of mercury is as shown in the figure. We find that at very low temperature, the resistance becomes zero.

Q.29. What is critical temperature?

Ans: When some metals and alloys are cooled to low temperature, resistivity suddenly becomes zero at a particular low temperature. This temperature is called critical temperature.

11.5 : Colour code for resistors :

Q.30. Write a short note on carbon resistor.

Ans: i. The carbon resistor is a mixture of powdered graphite and clay. They are formed in the shape of small cylinders with wire leads at the ends.

ii. The resistors are obtained in the range of 10 ohm to 22 mega ohm and are used in radio and television receivers.

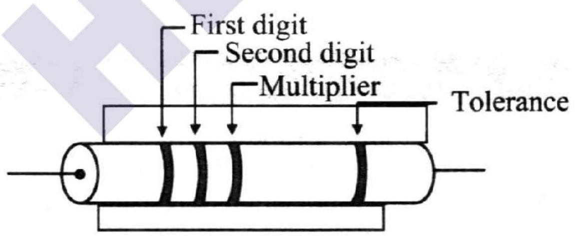
iii. They have four coloured bands on them. The colours correspond to the various digits to the numerical value of resistance.

iv. The colour coding of resistor is standardized by Electronic Industries Association (EIA).

Q.31. What is colour code? How is it used to determine the value of a resistor?

Ans: i. The colour code is the convenient way to indicate the value of the resistance, in the form of circular colour bands or rings round the resistor.

ii. In colour code system, generally a resistor has 4 bands on it. The band at the end of the resistor indicates the first digit, the next band towards the centre of the resistor indicates the second digit, the third band following two previous digits denotes the decimal multiplier, the fourth band indicates the tolerance (as shown in figure.)



Q.32. State the colour code system for resistors.

Ans: A carbon resistor contains four rings of different colours. Each colour represents a definite significant value, so they are called universal colour code.

Following table represent the colour code of carbon resistor.

Colour	Code	Multiplier	Tolerance (%)
Black	0	1	–
Brown	1	10^1	–
Red	2	10^2	–
Orange	3	10^3	–
Yellow	4	10^4	–
Green	5	10^5	–
Blue	6	10^6	–
Violet	7	10^7	–
Grey	8	10^8	–
White	9	10^9	–
Gold	–	10^{-1}	± 5%
Silver	–	10^{-2}	± 10%
No colour	–	–	± 20%

To remember the colours in order learn the Mnemonics : **B.B. ROY** of Great Britain had Very Good Wife.

Q.33. Explain the colour code system for resistors?

Ans: i. The carbon resistor is a mixture of powdered graphite and clay. They are formed in the shape of small cylinders with wire leads at the ends.

ii. The resistors are obtained in the range of 10 ohm to 22 mega ohm and are used in radio and television receivers.

iii. They have four coloured bands on them. The colours correspond to the various digits to the numerical value of resistance.

iv. The colour coding of resistor is standardized by Electronic Industries Association (EIA).

v. The colour code is the convenient way to indicate the value of the resistance, in the form of circular colour bands or rings round the resistor.

vi. In colour code system, generally a resistor has 4 bands on it. The band at the end of the resistor indicates the first digit, the next band towards the centre of the resistor indicates the second digit, the third band following two previous digits denotes the decimal multiplier, the fourth band indicates the tolerance.

Q.34. Explain with example, the use of colour code to represent the resistance of a resistor.

Ans: i. In a colour-coded resistance, value of the first two colours denote the first two digits, say x and y.

ii. The third colour denotes the digit, say z to be used as a power of 10 multiplier. So, the resistance value is $xy \times 10^z$.

Example: Let the colours of the three rings, of a resistor starting from one end be brown, red and orange. To determine resistance of resistor we have, x = 1, y = 2, z = 3 (From colour code table).

∴ Resistance $= xy \times 10^z$
$= 12 \times 10^3\ \Omega = 12\ k\Omega$

11.6 : Series and parallel combination of resistors :

Q.35. State and explain two combinations of resistors in an electric circuit.

Ans: The two combination of resistors are:

i. Series combination:

When a number of resistors are connected in series then the current flowing through each of them will be same.

a. If R_1, R_2 and R_3 are the three resistors connected in series as shown in figure. (a)

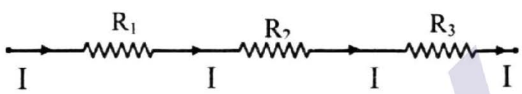


Figure (a)

Their equivalent resistance (R_S) is given by,

$R_S = R_1 + R_2 + R_3$

b. For on' resistors in senes combination,

$R_S = R_1 + R_2 + ... + R_n$

ii. Parallel combination:

When a number of resistors are connected in parallel, then the potential difference across each of them will be same.

a. If R_1, R_2 and R_3 are the three resistors connected in parallel as shown in figure. (b)

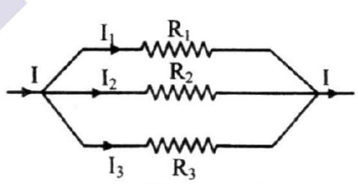


Figure (b)

Their equivalent resistance (R_p) is given by,

$$\frac{1}{R_P} = \left(\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}\right)$$

b. For n resistors in parallel combination,

$$\frac{1}{R_P} = \frac{1}{R_1} + \frac{1}{R_2} + ... + \frac{1}{R_n}$$

11.7 : E.M.F. and internal resistance of a cell :

Q.36. Define electromotive force (e.m.f.) of a cell. Discuss its unit and dimensions.

Ans: Electromotive force (e.m.f.):

i. The energy supplied by a cell to circulate a unit charge once round the complete circuit is called the electromotive force (E.M.F.) of the cell.

ii. If W is the energy supplied by the cell in circulating a charge 'q' once round the complete circuit then its electromotive force (E) is given by, $E = \frac{W}{q}$.

iii. Unit: SI unit of e.m.f is joule/coulomb or volt.

iv. Dimensions: $[M^1L^2T^{-3}A^{-1}]$

Q.37. Define potential difference of cell and state the relation between e.m.f and P.D of a cell.

Ans: Potential difference:

The energy spent by a source of e.mf in circulating unit charge through the external resistance is called potential difference (P.d.) of the cell.

Relation between e.m.f, and p.d:

$V = E - Ir$

where, V = potential difference
E = e.m.f. of the cell
I = current through the circuit
r = internal resistance of the cell

Q.38. Explain the following terms.

a. E.M.F

b. Terminal potential difference.

Ans: a. E.M.F:

i. The emf (E) of a cell is defined as the amount of work done in circulating a unit positive charge once round the complete circuit.

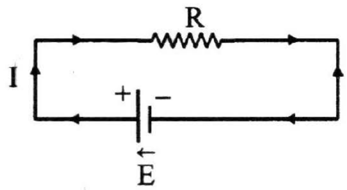
ii. For doing work, energy is obtained from chemical reaction taking place inside the cell.

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

It is a scalar quantity.
Its unit is J/C or volt.

iii. The source that produces potential difference. across a conductor is said to be the source of the e.m.f. When a resistance is connected between the terminals of a cell, electric charge flows round the closed circuit.

iv. Let us consider a simple circuit containing external resistance (R) and source of emf (E) as shown in figure.



Simple closed circuit

v. When a source of e.m.f. (cell) E is connected in an electric circuit, there is a flow of electrons (negative charge) from negative terminal to the positive terminal in external circuit.

vi. This is equivalent to flow of positive charge or electric current in the opposite direction. The cell (or battery) moves positive charge through external circuit from its positive terminal (higher potential) to negative terminal (lower potential).

vii. As charge flows, it has to perform work to overcome the resistance offered by the circuit.

viii. The function of cell is to supply energy so as to circulate the charge round the closed circuit.

b. Terminal potential difference.

i. The energy spent by source of e.mf in circulating unit positive charge through external resistance is called potential difference (p.d.) of the cell.

ii. Potential difference is measured across the cell terminal when cell is connected in circuit.

iii. To maintain charge flow in circuit, energy has to be supplied by source of emf.

iv. W_{AB} is work done in circulating charge +Q from A to B, then

$$\text{P.D.} = \frac{W_{AB}}{Q}$$

$$\therefore \quad V = \frac{W_{AB}}{Q}$$

v. Out of the total energy supplied by the cell, only part of the energy is used for overcoming external resistance.

vi. It is a scalar quantity.

vii. Its unit is J/C or volt.

Q.39. Explain application of Ohm's law to a complete circuit.

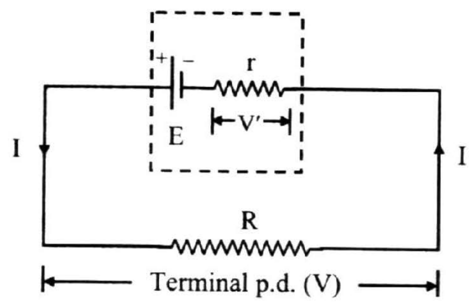
Ans: i. Consider a simple circuit containing external resistance R and a cell of emf E with internal resistance r as shown in figure.

ii. Let V be the terminal potential difference of a cell and V' be the p.d. across the internal resistance of the cell. Let 'I' be the current flowing through the circuit. ($I = \frac{q}{t}$).

iii. In time t, the charge flowing through the circuit is given by q = It.

iv. EMF is the energy supplied by the cell to send unit positive charge once round the circuit. Hence for sending charge q round the circuit, the total energy supplied by the cell is Eq. Out of the total energy, part of energy is spent in the external circuit.

v. Terminal potential difference being V, the energy spent in sending the charge q through it is Vq and remaining energy supplied is spent in overcoming internal resistance ofthe cell and it is V'q.



Circuit when external resistance connected to cell

vi. According to principle of conservation of energy,
Energy supplied = Energy spent

$\therefore$ Eq = Vq + V'q

$\therefore$ E = V + V'

vii. By Ohm's law, V = IR, V' = Ir

$\therefore$ E = V + Ir .... (1)

$\therefore$ E = IR + Ir

$\therefore$ E = I (R + r)

$\therefore$ $I = \frac{E}{R + r}$ .... (2)

Equation (2) gives relation between emf E, current I and resistance (R + r) for complete circuit. This is general equation of Ohm's law.

viii. Equation (1) can be written as,

V = E – Ir .... (3)

From equation (3) it is observed that terminal p.d. of a cell is less than the e.m.f of a cell.

Case 1:

If I = 0, then from equation (3),

E = V

Thus, the emf of a cell is equal to the p.d. between the terminals, when the cell is in open circuit i.e. when the cell is not delivering any current.

Case 2:

If I > 0, the cell is delivering current. This is called charging of a cell. In this case,

V = E – Ir

$\therefore$ V < E

Case 3:

If I < 0, current is driven through the cell. This is called discharging of the cell. In this case

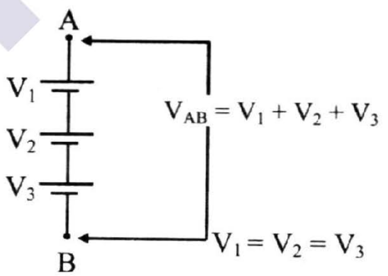
V = E + lr

$\therefore$ V > E

ix. From case 2, it is always desirable to have cell of smaller internal resistance.

Q.40. How can the voltage rating of a cell be increased?

Ans: i. A voltage higher than the voltage of one cell can be obtained by connecting cells in series as shown in figure.



Cells in Series

ii. In a given circuit, three cells are connected in series of same voltage ($V_1 = V_2 = V_3$).

iii. The negative terminal of first cell is connected to positive terminal of next cell and so on.

iv. This combination results in total addition of voltage ($V_1 + V_2 + V_3 = V_{AB}$).

$\therefore$ $V_{AB} = 3\ V_1 = 3\ V_2 = 3\ V_3$

v. However, the current carrying capacity of a battery of series combination is the same as that for one cell (if all the three cells have same voltage).

vi. Thus, voltage rating is increased by connecting them in series.

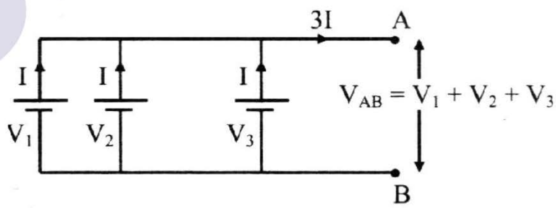
vii. However, in series combination effective internal resistance also increases.

Q.41. How can the current rating of a cell be increased?

Ans: i. The increase in current capacity can be obtained by connecting cells in parallel as shown in figure.

ii. In the given circuit, three cells each of same voltage are connected in parallel.

i.e. $V_1 = V_2 = V_3$



Cells in parallel

iii. For parallel combination, voltage and current rating of all the three cells must be same.

iv. Positive terminals of all the three cells are connected together which is positive terminals of the battery. Negative terminals of all the cells are connected together which is negative terminal of the battery.

v. If three cells are connected in parallel, the output voltage of battery remains the same and the current capacity of battery becomes three times the capacity of one cell.

vi. Thus, by connecting identical cells in parallel, current rating is increased.

11.8 : Work done by electric current :

Q.42. Explain work done by electric current through the electric circuit.

OR

Derive an equation for heat produced in the conductor when current flows through it.

Ans: i. When an electric current is passed through a conductor, it becomes hot, i.e. heat is generated. This is the heating effect of electric current. When p.d. is applied-across a conductor, electrons flow through it.

ii. While flowing, these electrons collide with atoms and other electrons, which gives rise to resistance of the conductor.

iii. In order to maintain the current, work has to be done in overcoming this resistance. This work done by the source is converted into heat.

iv. Let V be the p.d. across resistance R and I be the current flowing through the conductor.

v. When electric charge q moves against a potential difference of V, the amount of work done is given by $W = q\,V$

But current $I = q/t$ or $q = I\,t$

$\therefore$ $W = V\,I\,t$ .... (1)

Equation (1) represents work done by electric current in terms of potential difference, current and time.

vi. Also $V = I\,R$ [from Ohm's law]

From equation (1),

$W = I^2\,R\,t$

$W = V^2t/R$

This work done produces heat in the conductor, when current I flows through it for time 't'.

$\therefore$ Heat $= I^2\,R\,t$

i.e. $H = I^2\,R\,t$ ....(2)

Equation (2) represents heat produced in the conductor when current flows through it.

11.9 : Power in electric circuit :

Q.43. What is electric power? State its unit and dimensions.

Ans: i. The rate at which electric work is done is called electric power.

OR

The rate at which energy is drawn from the electric source is called electric power.

ii. Electric power (P) = $\dfrac{W}{t}$

iii. Unit: watt in SI system.

iv. If W = 1 J, t = 1 see then P = 1 watt.

Thus one watt power is the rate of doing one joule of electric work per second.

v. Dimensions: $[M^1L^2T^{-3}]$

Q.44. Deduce the formula for electric power in the electric circuit.

Ans: i. Let I = current flowing through electric circuit

R = Resistance of wire

V = Potential difference

W = Electrical work

ii. If P is the electric power of the electric circuit then from definition,

$$P = \frac{W}{t}$$

Also, $W = I^2\,Rt$

$$\therefore \quad P = \frac{I^2Rt}{t}$$

$\therefore$ $P = I^2R$

iii. From Ohm's law, $V = IR$,

$\therefore$ $P = VI$

Also $P = \dfrac{V^2}{R}$

iv. Commercial unit of power is kW or hP (horse power)

1 kW = 1000W

1 hP = 746 watt

Q.45. What is meant by electric energy?

Ans: Product of electric power and timefor flowing constant current through the circuit is called electric energy.

Electric energy is given by $W = Pt$

Electric energy is measured in kWh

1 kWh = 1000 watt hour

= 1000 watt × 60 × 60 see

$\therefore$ 1 kWh = 3.6×10^6 J = 3.6 MJ

Q.46. What is kilo-watt hour?

Ans: i. When an electric appliance rated 1000 watt is usedfor 1hour the energy consumed is 1 kWh.

ii. Electric energy consumed by us in daily life is measured by electric meter in a certain unit. This unit is called kilo-watt hour abbreviated as kWh.

iii. 1 kWh = 1 kilo-watt × 1 hour

= 1000 watt × 3600 s

= 3.6×10^6 joule

1 kWh = 3.6×10^6 J

11.10 : Elementary idea of secondary cells :

Q.47. Write a short note on secondary cells.

OR

Describe secondary cells in brief.

Ans: i. Those cells in which the reactions can be reversed by an external electric energy source, are known as secondary cells.

ii. These cells can be recharged by passing electric current and hence can be used again and again.

iii. In secondary cells, chemical energy gets converted into electrical energy and vice versa.

iv. Circuit diagram for charging and discharging of secondary cells is shown below:

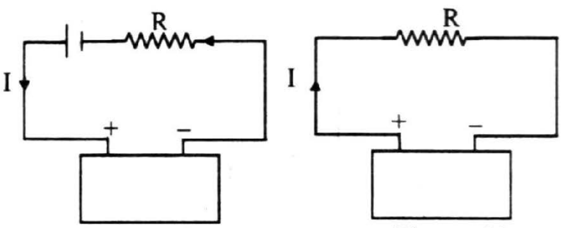


Figure (a) Charging **Figure (b) Discharging**

v. These are called accumulators or storage cells.

vi. Two examples of secondary cell:

a. Nickel- cadmium cell.

b. Lead acid accumulator.

Q.48. Distinguish between primary cells and secondary cells.

Ans:

	Primary cell	Secondary cells
i.	It is used only for discharge.	It is used for charging and can also be discharged.
ii.	Current can pass only in one direction .	Current can pass in both directions.
iii.	In primary cell, chemical energy gets converted into electrical energy.	In secondary cell, electrical energy gets converted into chemical energy and vice versa.
iv.	Example: Daniell cell, Voltaic cell	Example: Lead acid accumulator, Nickel cadmium cell

Formulae :

1. **Ohm's formula:**
$V = I R$

2. **Resistance:**
$$R = \frac{V}{I} = \rho\frac{l}{A}$$

3. **Specific resistance (Resistivity):**
$$p = \rho = \frac{RA}{l}$$

4. **Resistance of a conductor at t °C:**
$R_t = R_0 (1 + \alpha t)$

5. **Temperature coefficient of resistance:**
$$\alpha = \frac{R_t - R_0}{R_0 t}$$

6. **Equivalent resistance in series:**
$R_S = R_1 + R_2 + R_3 + ...$

7. **Equivalent resistance in parallel:**
$$\frac{1}{R_P} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + ...$$

8. **E.M.F. of a cell:**

i. $E = \frac{W}{q}$

ii. $E = I (R + r)$

9. **Internal resistance of a cell:**
$$r = R\left(\frac{E - V}{V}\right)$$

10. **Current through a group of cell:**

i. For n cells in parallel, $I = \frac{nE}{nR + r}$

ii. For n cells in series, $I = \frac{nE}{nR + r}$

iii. For mixed grouping, $I = \frac{mnE}{nR + r}$

11. **Heat produced by electric current in Joules:**

i. $H = I^2Rt$ ii. $H = VIt$

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

12. **Electric power:**

i. $W = Pt$

ii. $W = VIt$

iii. $P = I^2Rt$

13. Electric energy:

i. W = Pt

ii. W = VIt

iii. $P = I^2Rt$

14. Resistance of carbon resistor from colour code table:

$R = xy \times 10^Z \pm T$

Solved Examples :

Type I : Problems based on Ohm's law and resistivity

Example 1

A wire has resistance of 8 Ω. If its length is made half by folding, find its resistance after the free ends are connected to each others.

Solution:

Given : $R_1 = 8\,\Omega \quad \frac{l_2}{l_1} = \frac{1}{2}$

To find : Final resistance (R_2)

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

Calculation :

From formula,

$$R_1 = \rho\frac{l_1}{A_1},\ R_2 = \rho\frac{l_2}{A_2}$$

Specific resistance for same wire remains same. Volume of wire also remains same.

$\therefore \quad A_1 l_1 = A_2 l_2$

$\therefore \quad \frac{A_1}{A_2} = \frac{l_2}{l_1} = \frac{1}{2}$ ....(i)

Now $\frac{R_1}{R_2} = \frac{l_1}{l_2} \times \frac{A_2}{A_1} = \frac{l_1}{l_2} \times \frac{l_1}{l_2}$ ...... [From (i)]

$= \left(\frac{l_1}{l_2}\right)^2 = 2^2 = 4$

$\therefore \quad \frac{R_1}{R_2} = 4$

$\therefore \quad R2 = \frac{R_1}{4} = \frac{8}{4} = 2\,\Omega$

Ans: The resistance of the wire after connecting the free ends is $2\,\Omega$.

Example 2

Calculate the resistance of a wire of length 10 cm and diameter 1 mm.

[$\rho = 4.4 \times 10^{-7}\ \Omega$.m]

Solution:

Given : $l = 10$ cm $= 0.1$ m, d = 1 mm,
r = 0.5 mm = 5×10^{-4} m,
$\rho = 4.4 \times 10^{-7}\ \Omega$.m

To find : Resistance (R)

Formula : $R = \frac{\rho l}{A} = \frac{\rho l}{\pi r^2}$

Calculation :

From formula,

$$R = \frac{4.4 \times 10^{-7} \times 0.1}{3.14(5 \times 10^{-4})^2}$$

$$R = \frac{4.4 \times 10^{-7} \times 0.1}{7.85 \times 10^{-7}} = 0.056\ \Omega$$

Ans: The resistance of the wire is 0.056 Ω.

Example 3

The resistivity of nichrome is $10^{-6}\ \Omega$ m. What length of a uniform wire of this material and of 0.2 mm diameter will have a resistance of 200 ohm?

Solution:

Given: $\rho = 10^{-6}\ \Omega$ m, d = 0.2 mm
$\therefore$ r = 0.1 mm, R = 200 Ω

To find : Length (l)

Formula : $R = \frac{\rho l}{A} = \frac{\rho l}{\pi r^2}$

Calculation :

From formula,

$$l = \frac{RA}{\rho} = \frac{R\pi r^2}{\rho}$$

$$l = \frac{200 \times 3.142 \times (1 \times 10^{-4})^2}{10^{-6}} = \mathbf{6.28\ m}$$

Ans: The length of the nichrome wire is **6.28 m**.

Example 4

A constantan wire of length 50 cm and 0.4 mm diameter is used in making a resistor. If the resistivity of constantan is $5 \times 10^{-7}\ \Omega$-m, calculate the value of the resistor.

Solution:

Given : I = 50 cm = 0.5 m,
d = 0.4 mm = 0.4×10^{-3} m,
r = 0.2×10^{-3} m,
$\rho = 5 \times 10^{-7}\ \Omega$ m

To find : Value of resistor (R)

Formula : $R = \rho = \frac{l}{A} = \frac{\rho l}{\pi r^2}$

Calculation :
From formula,

$$R = \frac{5\times10^{-7}\times0.5}{3.14\times(0.2\times10^{-3})^2}$$

$$= \frac{2.5\times10^{-7}}{3.14\times0.04\times10^{-6}}$$

$$= \frac{2.5\times10^{-7}}{3.14\times0.4\times10^{-7}}$$

$\therefore \quad R = 1.99\ \Omega$

Ans: The value of the resistor is **1.99 Ω**.

Example 5

A negligibly small current is passed through a wire of length 15 m and uniform cross-section 6 × 10⁻⁷ m², and its resistance is measured to be 5 Ω. What is the resistivity of the material at the temperature of the experiment? (NCERT)

Solution:

Given : $l = 15$ m, $A = 6.0\times10^{-7}$ m², $R = 5\,\Omega$

To find : Resistivity (ρ)

Formula : $\rho = \frac{RA}{l}$

Calculation :
From formula,

$$\rho = \frac{5\times6\times10^{-7}}{15}$$

$\therefore \quad \rho = \mathbf{2\times10^{-7}\ \Omega\,m}$

Ans: The resistivity of the material is **$2\times10^{-7}\ \Omega$ m**.

Example 6

A wire of circular cross-section and 30 ohm resistance is uniformly stretched until its new length is three times its original length. Find its resistance.

Solution:

Given : $R_1 = 30$ ohm,
l_1 = original length,
A_1 = original area
l_2 = new length, $\therefore \quad l_2 = 3l_1$

To find : Resistance (R_2)

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

Calculation :
From formula,

$$R_1 = \rho\frac{l_1}{A_1} \quad ....(1)$$

$$R_2 = \rho\frac{l_2}{A_2} \quad ....(2)$$

Divide equation (1) by (2), we get,

$$\frac{R_1}{R_2} = \frac{\rho\frac{l_1}{A_1}}{\rho\frac{l_2}{A_2}}$$

$$\therefore \quad \frac{R_1}{R_2} = \frac{l_1}{l_2}\cdot\frac{A_2}{A_1} \quad ....(3)$$

The volume of wire remains the same in two cases, we have

$$l_1A_1 = l_2A_2$$

$$\therefore \quad \frac{A_2}{A_1} = \frac{l_1}{l_2} \quad .... (4)$$

From equations (3) and (4),

$$\frac{R_1}{R_2} = \frac{l_1}{l_2}\cdot\left(\frac{l_1}{l_2}\right)$$

$$\therefore \quad \frac{R_1}{R_2} = \left(\frac{l_1}{l_2}\right)^2$$

$$\therefore \quad \frac{R_1}{R_2} = \left(\frac{l_1}{3l_2}\right)^2$$

$$\therefore \quad \frac{R_1}{R_2} = \frac{1}{9}$$

$\therefore \quad R_2 = 9R_1 = 9\times30 = \mathbf{270\,\Omega}$

Ans: The new resistance of the wire is **270 Ω**.

Type II : Problems based on temperature coefficient

Example 7

The resistance of a tungsten fllament at 150°C is 133 ohm. What will be its resistance at 500 °C? The temperature coefficient of resistance of tungsten is 0.0045 per °C.

Solution:

Given : Let resistance at 150°C be R_1 and resistance at 500°C be R_2

Thus,

$R_1 = 133\ \Omega,\ \alpha = 0.0045\ °C^{-1}$

To find : Resistance (R_2)

Formula : $R_1 = R_0\ (1 + \alpha t)$

Calculation :

From formula,

$R_1 = R_0\ (1 + \alpha \times 150)$

$\therefore\ 133 = R_0\ (1 + 0.0045 \times 150)$ .... (1)

$R_2 = R_0\ (1 + a \times 500)$

$\therefore\ R_2 = R_0\ (1 + 0.0045 \times 500)$ .... (2)

Dividing equation (2) by (1), we get

$$\frac{R_2}{133} = \frac{1+0.0045\times500}{1+0.0045\times150} = \frac{3.25}{1.675}$$

$$R_2 = \frac{3.25}{1.675} \times 133 = \mathbf{258\ \Omega}$$

Ans: The resistance of tungsten filament at 500°C is **258** Ω.

Example 8

A conductor has resistance of 15 Ω at 10°C and 18 Ω at 400 °C. Find the temperature coefficient of resistance of the material.

Solution:

Given : $R_1 = 15\ \Omega,\ t_1 = 10\ °C,$

$R_2 = 18\ \Omega,\ t_2 = 400°C$

To find : Temperature coefficient of resistance (α)

Formula : $R_t = R_0\ (1 + \alpha t)$

Calculation :

From formula,

$R_1 = R_0\ (1 + \alpha \times 10)$ ....(1)

$R_2 = R_0\ (1 + \alpha \times 400)$ ....(2)

Dividing equation (1) by (2), we have,

$$\frac{R_1}{R_2} = \frac{1+\alpha\times10}{1+\alpha\times400}$$

$$\therefore\ \frac{15}{18} = \frac{1+10\alpha}{1+400\alpha}$$

$\therefore\ 18 + 180\ \alpha = 15 + 6000\ \alpha$

$\therefore\ 5820\ \alpha = 3$

$$\therefore\ \alpha = \frac{3}{5820} = 5.15 \times 10^{-4}\ /°C$$

Ans: The temperature coefficient of resistance of the material is $\mathbf{5.15 \times 10^{-4}\ /°C}$.

Example 9

A silver wire has resistance of 2.1 Ω at 27.5 °C. If temperature coefficient of silver is 3.94 × 10^{-3} /°C, find the silver wire resistance at 100°C.

Solution:

Given : $R_1 = 2.1\ \Omega,\ t_1 = 27.5\ °C,$

$\alpha = 3.94 \times 10^{-3}\ /°C,\ t_2 = 100°C$

To find : Resistance (R_2)

Formula : $R_1 = R_0\ (1 + \alpha t)$

Calculation :

From the formula,

$R_1 = R_0\ (1 + \alpha \times 27.5)$ ....(1)

$R_2 = R_0\ (1 + \alpha \times 100)$ ....(2)

Dividing equation (1) by (2), we get,

$$\frac{R_1}{R_2} = \frac{1+3.94\times10^{-3}\times27.5}{1+3.94\times10^{-3}\times100}$$

$$\frac{R_1}{R_2} = \frac{1.10835}{1.394} = 0.795$$

$$\therefore\ R_2 = \frac{R_1}{0.795} = \frac{2.1}{0.795} = 2.6\ \Omega$$

Ans: The resistance of silver WIre at 100°C is $2.6\ \Omega$.

Example 10

A silver wire has a resistance of 2.1 Ω at 27.5 °C and a resistance of 2.7 Ω at 100°C. Determine the temperature coefficient of resistance of silver. (NCERT)

Solution:

Given : $R_1 = 2.1\ \Omega,\ t_1 = 27.5\ °C$

$R_2 = 2.7\ \Omega,\ t_2 = 100°C$

To find : Temperature coefficient of resistance (α)

Formula : $R_1 = R_0\ (1 + \alpha t)$

Calculation :

From formula,

$R_1 = R_0\ (1 + \alpha \times 27.5)$ ....(1)

$R_2 = R_0\ (1 + \alpha \times 100)$ ....(2)

Divide equation (1) by (2), we have,

$$\frac{R_1}{R_2} = \frac{1+27.5\alpha}{1+100\alpha}$$

$$\therefore\ \frac{2.1}{2.7} = \frac{1+27.5\alpha}{1+100\alpha}$$

$$\therefore\ \frac{7}{9} = \frac{1+27.5\alpha}{1+100\alpha}$$

$\therefore\ 7 + 700\ \alpha = 9 + 247.5\ \alpha$

$\therefore\ 452.5\ \alpha = 2$

$\therefore\ \alpha = 0.0044\ °C^{-1}$ or $4.4 \times 10^{-3}\ °C^{-1}$.

Ans: The temperature coefficient of resistance of silver is **0.0044 °C^{-1}** or **4.4 × 10^{-3}** °C^{-1}.

Type III : Problems based on colour code of resistor

Example 11

The colour bands marked on the carbon resistor are orange, green, orange, silver. Find the resistance of the resistor.

Solution:

Given : orange - green - orange - silver

To find : Value of resistance

Formula : Value of the resistance

$= xy \times 10^{z}\ \Omega \ \pm T\%\Omega$

Calculation :

According to colour code table, we have,

Orange	Green	Orange	Silver
3	5	3	±10%

Here x = 3, y = 5, z = 3, T = 10%.

∴ From formula,

value of resistance $= 35 \times 10^{3} \pm 10\ \%$

$= (35{,}000 \pm 3500)\ \Omega$

Ans: The value of resistance is **(35,000 ± 3500)** Ω.

Example 12

The colour bands denoted on the resistor are yellow, green, red, no colour. What is the resistance value?

Solution:

Given : yellow - green - red - No colour.

To find : Value of resistance

Formula : Value of the resistance

$= xy \times 10^{z}\Omega \pm T\%\Omega$

Calculation :

Following the colour cOde table, we have

Yellow	Green	Red	No colour
4	5	2	±20%

Here, x = 4, y = 5, z = 2, t = ± 20%.

From formula,

The value of the resistor is $= 45 \times 10^{2} \pm 20\%$

$= \mathbf{(4500 \pm 900)}\ \Omega$

Ans: The value of resistance is **(4500 ± 900)** Ω.

Example 13

A carbon resistor has the following colour bands in order: Red, green, blue and silver. How much resistance is indicated?

Solution:

Given : Red - Green - Blue - Silver

To find : Value of resistance

Formula : Value of the resistance

$= xy \times 10^{z}\Omega \pm T\%\Omega$

Calculation :

Colour	Red x	Green y	Blue z	Silver T%
Colour	2	5	6	±10

Here, x = 2, y = 5, z = 6, T = 10%

∴ Value of resistance $= xy \times 10^{z}\ \Omega \pm T\%\Omega$

$= 25 \times 10^{6}\ \Omega \pm 10\%\Omega$

[Note: ± 10% of $25 \times 10^{6}\ \Omega$ is $25 \times 10^{5}\ \Omega$]

The value of the resistance is

$(25 \times 10^{6} \pm 10\%)\Omega = (25 \times 106 \pm 25 \times 10^{5})\ \Omega$

Ans: The value of the resistance is **(25 × 10^{6} ± 25 × 10^{5})** Ω.

Type IV : Series and parallel combination of resistors

Example 14

i. **Three resistors 1 Ω, 2 Ω and 3 Ω are combined in series. What is the total resistance of the combination?**

ii. **If the combination is connected to a battery of e.m.f. 12 V and negligible internal resistance, obtain the potential drop across each resistor. (NCERT)**

Solution:

Given : $R_1 = 1\ \Omega, R_2 = 2\ \Omega, R_3 = 3\ \Omega$, V = 12 V

To find : i. Total resistance (R)

ii. P. D. across R_1, R_2 and R_3 (V_1, V_2 and V_3 respectively)

Formulae : i. $R_s = R_1 + R_2 + R_3$

ii. V = IR

Calculation :

From formula (i),

$R_s = 1 + 2 + 3 = 6\Omega$

From formula (ii),

$$I = \frac{V}{R} = \frac{12}{6} = 2\ A$$

∴ $V_1 = IR_1 = 2 \times 1 = 2\ V$

∴ $V_2 = IR_2 = 2 \times 2 = 4\ V$

∴ $V_3 = IR_3 = 2 \times 3 = 6\ V$

Ans: i. The total resistance of the combination is **6** Ω.

ii. The p.d.across R_1, R_2 and R_3 are 2V, 4V and 6V respectively.

Example 15

i. **Three resistors 2 Ω, 4 nand 5 Ω are combined in parallel. What is the total resistance of the combination ?**

ii. **If the combination is connected to a batter) of e.m.f. 20 V and negligible internal resistance, determine the current through each resistor and the total current drawn from the battery. (NCERT)**

Solution:

Given : $R_1 = 2\ \Omega, R_2 = 4\ \Omega, R_3 = 5\ \Omega$, V = 20 V

To find : i. Total resistance (R)

ii. Current through each resistor (I_1, I_2, I_3 respectively)

iii. Total current (1)

Formula : i. $\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$

ii. V = IR

iii. Total current, $I = I_1 + I_2 + I_3$

Calculation :

From formula (i),

$$\frac{1}{R} = \frac{1}{2} + \frac{1}{4} + \frac{1}{5} = \frac{19}{20}$$

$$\therefore \quad R = \frac{20}{19}\Omega$$

From formula (H),

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

$$\therefore \quad I_1 = \frac{V}{R_1} = \frac{20}{2} = 10\ A$$

$$I_2 = \frac{V}{R_2} = \frac{20}{4} = 5\ A$$

$$I_3 = \frac{V}{R_3} = \frac{20}{5} = 4\ A$$

From formula (iii),

I = 10 + 5 + 4

∴ I = **19 A**

Ans: i. The total resistance of the combination is $\frac{20}{19}\Omega$.

ii. The currents through R_1 R_2 and R_3 are 10 A, 5 A and 4 A respectively.

iii. The total current drawn is 19 A.

Type V : Problems based on E.M.F. of cell

Example 16

A cell of e.m.f. 2 V and internal resistance 4 Ω is connected to an external resistance of 12 Ω. Find the terminal P .D. of the cell.

Solution:

Given : E = 2 volt, r = 4 Ω, R = 12 Ω

To find : Terminal P.D. (V)

Formula : i. $I = \frac{E}{R + r}$

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

where V is the terminal P.D. of the cell.

Calculation :

Equating formulae (i) and (ii) we get,

$$\frac{E}{R + r} = \frac{V}{R}$$

$$\therefore \quad \frac{2}{12 + 4} = \frac{V}{12}$$

$$\therefore \quad V = \frac{3}{2} = \mathbf{1.5\ V}$$

Ans: The terminal potential difference of the cell is **1.5 V**.

Example 17

Find the potential difference between terminals of the battery if 240 joule of work is required to transfer 20 coulomb of charge from one terminal to the other terminal.

Solution:

Given : w = 240 J, q = 20 C

To find : Potential difference between terminals (V)

Formula : $V = \frac{W}{q}$

Calculation :

From formula,

$$V = \frac{240}{20} = \mathbf{12\ volt}$$

Ans: The potential difference between the terminals of the battery is **12 V**.

Example 18

A voltmeter is connected across a battery of emf 12 V and internal resistance of 10 Ω. If the voltmeter resistance is 230 Ω, what reading will be shown by the voltmeter?

Solution:

Given: $E = 12$ volt, $r = 10\,\Omega$, $R = 230\,\Omega$

To find: Reading shown by voltmeter (V)

Formulae: i. $I = \dfrac{E}{R+r}$

ii. $V = E - Ir$

Calculation:

From formula (i),

$$I = \frac{12}{230+10} = \frac{12}{240} = \frac{1}{20}\ \text{A}$$

From formula (ii),

$$V = 12 - \frac{1}{20} \times 10 = 12 - 0.5 = \mathbf{11.5\ volt}$$

Ans: The reading shown by the voltmeter is **11.5 V**.

Example 19

A battery of e.m.f. 10 V and internal resistance 3 Ω is connected to a resistor. If the current in the circuit is 0.5 A, what is the resistance of the resistor? What is the terminal voltage of the battery when the circuit is closed? (NCERT)

Solution:

Given: $E = 10$ V, $r = 3\ 0\,\Omega$, $1 = 0.5$ A

To find: i. Resistance of resistor (R)

ii. Terminal voltage of battery (V)

Formula: $I = \dfrac{E}{R+r}$

Calculation:

From formula,

$$R = \frac{E}{I} - r$$

$$\therefore \quad R = \frac{10}{0.5} - 3 = 17\ \Omega$$

$$\therefore \quad V = IR = 0.5 \times 17 = \mathbf{8.5\ volt}$$

Ans: i. The resistance of the resistor is **17 Ω**.

ii. The terminal voltage of the battery when the circuit is closed is **8.5 V**.

Type VI : Problems based on heating effect of current

Example 20

A 10 V storage battery of negligible internal resistance is connected across a 50 Ω resistor made of alloy manganin. How many calories of heat energy is produced in the resistor in 1 hr?

Solution:

Given: $V = 10$ V, $R = 50\ \Omega$, $t = 1$ hr $= 3600$ s

To find: Heat produced in cal (H)

Formula: i. $H = \dfrac{V^2 t}{R}$

ii. $1\ \text{cal} = \dfrac{1}{4.18}\,\text{J}$

Calculation:

From formula (i),

$$H = \frac{10 \times 10 \times 3600}{50} = 7200\ \text{J}$$

From formula (ii),

$$H\ (\text{in cal}) = \frac{7200}{4.18}\ \text{cal} = \mathbf{1722.49\ cal.}$$

Ans: The heat produced in the resistor is **1722.49 cal**.

Type VII : Electric power

Example 21

Calculate the current flowing through a heater rated at 2 kW when connected to a 300 V d.c. supply.

Solution:

Given: $P = 2$ kW $= 2000$ W, $V = 300$ V

To find: Current (1)

Formula: $I = \dfrac{P}{V}$

Calculation:

From formula,

$$I = \frac{2000}{300} = \mathbf{6.67\ A}$$

Ans: The current flowing through the heater is **6.67 A**.

Example 22

Calculate the electric bill at the end of a month of 30 days at Rs. 2.00 per unit if 6 lamps of 40 watt burn for 8 hours per day, an electric iron of 1 kW is used for 2 hours per day and 4 fans of 50 watt are used for 10 hours per day.

Solution:

Total energy consumed per day = P × t
= (6 × 40 × 8) + (1000 × 2) + (4 × 50 × 10)
= 5920 W.hr/day

$= \frac{5920}{1000}$ kWh = 5.92 kWhr/day

∴ Total energy used in 30 days = 5.92 × 30
= 177.6 kWhr

∴ Total unit consumed in 30 days = 177.6

∴ Electric bill for the month = 177.6 × 2
= **Rs. 355.20**

Ans: The electric bill at the end of month of 30 days is **Rs. 355.20**.

Type VIII : Miscellaneous

Example 23

At what temperature would the resistance of a copper conductor be double its resistance at 0 °C?
[α for copper = 3.9 × 10^{-3}/°C]

Solution:

Given :
Let the resistance of the conductor at 0 °C be R_0

∴ $R_1 = R_0$, $t_1 = 0$ °C
$R_2 = 2R_0$, $t_2 = t$ °C

To find : Final temperature (t2)

Formula : $\alpha = \frac{R_2 - R_1}{R_1(t_2 - t_1)}$

Calculation :
From formula,

$$\alpha = \frac{2R_0 - R_0}{R_0(t - 0)} = \frac{1}{t}$$

$$\therefore \quad t = \frac{1}{\alpha} = \frac{1}{3.9 \times 10^{-3}} = 256°C$$

Ans: The final temperature of the copper conductor is **256°C**.

Example 24

An electric heater takes 6 A current from 220 V upply line. Calculate the power of heater and electric energy consumed by it in 2 hours.

Solution:

Given : I = 6 A, V = 220 volt, t = 2 hour

To find : i. Power of heater (P)
ii. Electric energy consumed (E)

Formula : i. P = VI
ii. Electric energy consumed = P×t

Calculation :
From formula (i),
P = 220 × 6 = 1320 W
∴ **P > 1.32 kW**
From formula (ii),
Electric energy consumed = 1.32 × 2 = **2.64 kWh**

Ans: i. The power of the heater is **1.32 kW.**
ii. The electric energy consumed by the heater in 2 hours is **2.64 kWh.**

Example 25

How many cells each of 1.5 V/500 mA rating would be required in series-parallel combination to provide 1500 mA at 3 V?

Solution:

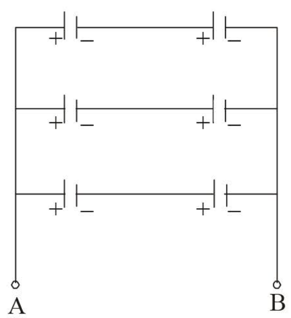
$V_1 = V_2 = ... = 1.5V$ (given)
$I_1 = I_2 = ... = 500$ mA (given)
1500 mA at 3 V is required, so number of cells ar
For series $V = V_1 + V_2 + ...$, and current remains same.
For parallel $I = I_1 + I_2 + ...$, and voltage remains same.
To achieve battery output of 3V, the cells should be connected in series.
If n are the number of cells connected in series, then

$V = V_1 + V_2 + ... + V_n$
∴ $V = nV_1$
∴ $3 = n \times 1.5$
∴ n = 2 cells in series

The series combination of two cells in series will give a current 500 mA.
To achieve output of 1500 mA, the number of batteries (n) connected in parallel, each one having output 3V is,

$I = I_1 + I_2 + ... I_n$
∴ $I = nI_1$
∴ 1500 = n × 500
∴ n = 3 batteries each of two cells
∴ No of cells required are 2 × 3 = 6
∴ Number of cells = 6

The six cells must be connected as shown:



Ans: The number of cells required is **6**.

Example 26

A carbon resistor has a resistance of $(67 \times 10^5 \pm 5\%)\,\Omega$. Write down the colour of the bands in order.

Solution:

Given : Value of resistor $= (67 \times 10^5 \pm 5\%)\,\Omega$

To find : Colour of the bands in order

Formula : Value of resistor $= xy \times 10^z\ \Omega \pm T\%\,\Omega$

Calculation :

$\therefore$ Value of resistor $= (67 \times 10^5 \pm 5\%)\,\Omega$
$= 67 \times 10^5\,\Omega \pm 5\%\,\Omega$

Comparing this with the formula,

Value of resistor $= xy \times 10^z\ \Omega \pm T\%\,\Omega$

here x = 6, y = 7, z = 5, T = 5%

Referring to colour code table

The first ring/colour for x = 6 is blue

The second ring/colour for y = 7 is violet

The third ring/colour for z = 5 is green

The fourth ring/colour for T = 5% is gold

Hence colour bands on the given resistor are

Blue - Violet - Green - Gold

Ans: The colours of the bands of the resistor are **Blue - Violet - Green - Gold**.

Example 27

Evaluate resistance for the following colourcoded resistors:

i. Yellow - Violet -Black - Silver

ii. Green - Blue - Red - Golden

iii. Brown - Black - Orange - Golden

Solution:

i. Given: Yellow - Violet -Black -Silver

To find : Value of resistance

Formula : Value of resistance $= (xy \times 10^z \pm T\%)\,\Omega$

Calculation :

Colour	Yellow	Violet	black	Silver
code	4	7	0	±10

Hence x = 4, y = 7, z = 0, T = 10%

Value of resistance $= (xy \times 10^z \pm T\%)\,\Omega$
$= (47 \times 10^\circ \pm 10\%)\,\Omega$

Value of resistance = $\mathbf{(47 \pm 10\%)\ \Omega}$

ii. Given: Green - Blue Red - Gold

To find : value of resistance

Formula : value of resistance $= (xy \times 10^z \pm T\%)\,\Omega$

Calculation :

Colour	Green x	Blue y	Red z	Gold T%
Code	5	6	2	±5

Hence x = 5, y = 6, z = 2, T = 5%

$\therefore$ Value of resistance $= (xy \times 10^z \pm T\%)\,\Omega$
$= (56 \times 10^2 \pm 5\%)\,\Omega$

iii. Given: Brown - Black - Orange - Gold

To find : Value of the resistance

Formula : Value of the resistance $= (xy \times 10^z \pm T\%)$

Calculation:

Colour	Brown x	Black Y	Orange Z	Gold T%
Code	1	0	3	±5

Hence x = 1, y = 0, z = 3, T = 5%

$\therefore$ Value of resistance $= (xy \times 10^z \pm T\%)\ \Omega$
$= (10 \times 10^3 \pm 5\%)\,\Omega$

Ans: The value of the given resistance is

i. $\mathbf{(47 \pm 10\%)\ \Omega}$

ii. $\mathbf{(56 \times 10^2 \pm 5\%)\ \Omega}$

iii. $\mathbf{(10 \times 10^3 \pm 5\%)\ \Omega}$.

Additional Theory Questions :

Q.1. Define:

i. Specific resistance

ii. Thermistor

iii. PTC thermistor

iv. NTC thermistor

v. Superconductor

vi. Electric power

vii. Electric energy

viii. Kilo-watt-hour

Ans: i. Refer Q. 14. (ii)

ii. Refer Q.21.

iii. Refer Q.24 (i)

iv. Refer Q.24 (ii).

v. Refer Q.26 (A).

vi. Refer Q.43.

vii. ReferQ.45

viii. Refer Q.46.

Practice Problems :

Type I : Problems based on Ohm's law and resistivity

1. The resistance of a conducting wire of length 1.1 m and of diameter 0.14 mm is 30 Ω. Calculate its resistivity.
2. A metal wire of specific resistance 64×10^{-6} Ω m and length 1.98 cm has a resistance of 7 Ω. Find its radius.
3. A wire of resistance 100 is drawn out so that its length is thrice its original length. Calculate its new resistance (resistivity and density of the material remain unchanged).
4. Length of a wire of resistance 20 Ω is doubled on stretching. Calculate its new resistance.

Type II: Problems based on temperature coefficient

5. A platinum wire has a resistance of 10 Ω at 0 °C and of 20 Ω at 273°C. Find its temperature coefficient of resistance.

Type III : Problems based on colour code of resistor

6. The following bands in a given order appear on a carbon resistor. Write the indicated value of the resistance. Orange, Brown, Violet, Gold.

Type IV: Problems based on E.M.F. of cell

7. Three identical cells, each of emf 2 V and internal resistance 0.2 Ω are connected in series to an external resistor of 7.4 Ω. Calculate the current in the circuit.
8. A cell of E.M.F 2 volt and internal resistance of 4/3 ohm is connected to two resistances of 10 ohm and 20 ohm joined in parallel. Find the current through each resistance.
9. A cell of emf E volt and internal resistance 'r' when connected to an external resistance of 3 Ω gives a current of 3 A. When it is connected to a resistance of 12 Ω it gives a current of 1.2 A. Find E and r.

Type V : Problems based on heating effect of current

10. An electric current of 2.0 A passes through a wire of resistance 25 Ω. How much heat will be developed in 1 minute?
11. A heating oil bath contains 400 g of oil. An electric heater of 100 W is used to heat the oil. Find the rise in temperature of oil in 10 minutes assuming no heat is lost outside. [Specific heat of oil = 0.7cal 1 g °C, J = 4.2 J/cal.]

Type VI: Electric power

12. In a house there are 10 lamps each of 60 W, 4 fans each of 1/8 hp and other electrical appliances which consume 1627 W. If all these are used for 4 hours a day on an average, find the cost of electrical energy consumed in a month of April. One unit of power consumed is charged at the rate of Rs. 1.25.
13. Calculate the electric bill for the month of June at Rs. 2 per unit, if 6 lamps of 40 W lights for 8 hours per day, a washing machine of 1 kW is used for 2 hours per day and 2 fans of 100 W are used for 10 hours per day.
14. In an office room, 24 lamps each of 60 W and 6 ceiling fans, each of 0.1 kW are used for 6 hours a day. Calculate the electricity bill for the month of November, if the cost per unit is Rs. 2.
15. How much work is done in moving a charge of 1.2 C from a point at 100 V to 180 V?

Type VII: Miscellaneous

16. Calculate the resistance of 2 m long nichrome wire of radius 0.321 mm. Resistivity of nichrome is 15×10^{-6} Ωm. If a potential difference of 10 V is applied across this wire, what will be the current in the wire?
17. The resistance of a silver wire at 0 °C is 1.25 Ω. Upto what temperature it must be heated so that its resistance is doubled? [The temperature coefficient of resistance of silver is 0.00375 $°C^{-1}$]
18. A battery supplies a current of 0.9 A through a 2 Ω resistor and a current of 0.3 A through a 7 Ω resistor. Calculate the emf and internal resistance of the battery.
19. A resistance of 12 Ω takes 8 minutes to boil a given amount of water. If another resistance takes 4 minutes to boil the same amount of water using the same source, then what will be its resistance?
20. A wire has a resistance of 15 Ω at 10°C and 18 Ω at 400°C. Find the temperature coefficient of its resistance.
21. The emf of a cell is 6 V. When the cell is used to send a current through an external resistance of 10 Ω, the p.d. between the terminals of the cell

is 5.5 volt. Find the internal resistance of the cell.

22. A carbon resistor has the following colours. First ring brown, second ring blue, third orange and fourth silver. What is the resistance of the resistor?

23. A wire of resistance 48 Ω is uniformly stretched until its length increases by 25%. Find the new resistance.

24. Find the time required in minutes to produce 2400 cal of heat when a current of 1 A flows through a wire of resistance 4.18 Ω. (J = 4.18 J/cal)

25. A potential difference of 200 V is maintained across a conductor and current flowing through it is 2 A. Find

i. resistance and

ii. charge flowing through resistor for 15 seconds

iii. the number of electrons flowing through the conductor in 15 seconds.

[Charge on electron = 1.6×10^{-19} C]

26. A 60 W – 220 V bulb and 100 W – 220 V bulb are connected in parallel to mains supply. Which bulb will draw more current?

Multipal Choice Questions

1. Which of the following has negative temperature coefficient of resistance?

a) Tungsten b) Carbon
c) Nichrome d) Platinum

2. The SI unit of the emf of a cell is

a) V/m b) V/C
c) J/C d) C/J

3. The terminal voltage across a cell is more than its e.m.f., if another cell of

a) higher e.m.f. is connected parallel to it.
b) less e.m.f. is connected parallel to it.
c) less e.m.f. is connected in series with it.
d) higher e.m.f. is connected in series with it.

4. A cell of emf E and internal resistance r is connected across an external resistance R (R >> r). The p.d, across R is

a) $\frac{E}{R+r}$ b) $E.\left(1-\frac{r}{R}\right)$
c) $E.\left(1+\frac{r}{R}\right)$ d) E (R + r)

5. Emf of a cell is 2.2 volt. When resistance R = 5 Ω is connected in series, potential drop across the cell becomes 1.8 volt. Value of internal resistance of the cell is

a) 10/9 Ω b) 7/12 Ω
c) 9/10 Ω d) 12/7 Ω

6. A 100 W, 200 V bulb is connected to a 160 volt supply. The actual power consumption would be

a) 64 W b) 125 W
c) 100 W d) 80W

7. The e.m.f. of a cell of negligible internal resistance is 2 V. It is connected to the series combination of 2 Ω, 3 Ω and 5 Ω resistances. The potential difference across 3 Ω resistance will be

a) 0.6 V b) 10 V
c) 3 V d) 6 V

8. When potential difference is applied across an electrolyte, then Ohm's law is obeyed at

a) zero potential b) very low potential
c) negative potential d) high potential.

9. A potential difference of 20 V is applied across the ends of a coil. The amount of heat generated in it is 800 cal/s. The value of resistance of the coil will be

a) 12 Ω b) 1.2 Ω
c) 0.12 Ω d) 0.012 Ω

10. The unit of specific resistance is

a) $\Omega\ m^{-1}$ b) $\Omega^{-1}\ m^{-1}$
c) $\Omega\ m$ d) $\Omega\ m^{-2}$

11. If the length of a conductor is halved, then its conductivity will be

a) doubled b) halved
c) quadrupled d) unchanged

12. A P.D. of 20 V is applied across a conductance of 8 mho. The current in the conductor is

a) 2.5 A b) 28 A
c) 160 A d) 45 A

13. If an increase in length of copper wire is 0.5% due to stretching, the percentage increase in its resistance will be

a) 0.1% b) 0.2 %
c) 1% d) 2 %

14. If a certain piece of copper is to be shaped into a conductor of minimum resistance, its length (L) and cross-sectional area A shall be respectively

a) L/3 and 4 A b) L/2 and 2 A

c) 2L and A2 d) L and A

15. Specific resistance of copper, constantan and silver are 1.78×10^{-8}, 39.1×10^{-8} and 10^{-8} Ω m respectively. Which of these is the best conductor of heat and electricity ?

a) copper b) constantan

c) silver d) all of them.

16. A given resistor has the following colour scheme of the various strips on it : Brown, black, green and silver. Its value in ohm is

a) $1.0 \times 10^4 \pm 10\%$ b) $1.0 \times 10^5 \pm 10\%$

c) $1.0 \times 10^6 \pm 10\%$ d) $1.0 \times 10^7 \pm 10\%$

17. A given carbon resistor has the following colour code of the various strips : Orange, red, yellow and gold. The value of resistance in ohm is

a) $32 \times 10^4 \pm 5\%$ b) $32 \times 10^4 \pm 10\%$

c) $23 \times 10^5 \pm 5\%$ d) $23 \times 10^5 \pm 10\%$

18. Constantan wire is used for making standard resistance, because it has

a) high melting point

b) low specific resistance

c) high specific resistance

d) negligible temperature co-efficient of resistance

19. Thermistors are usually prepared from

a) non-metals

b) metals

c) oxides of non-metals

d) oxides of metals

20. A typical thermistor can easily measure a change in temperature of the order of

a) 10^{-3} °C b) 10^{-2} °C

c) 10^2 °C d) 10^3 °C

21. Which of the following is used for the formation of thermistor?

a) copper oxide b) nickel oxide

c) iron oxide d) all of the above

22. On increasing the temperature of a conductor, its resistance increases because

a) relaxation time decreases.

b) mass of the electron increases.

c) electron density decreases.

d) all of the above.

23. The resistance of a metal conductor increases with temperature due to

a) change in current carriers.

b) change in the dimensions of the conductor.

c) increase in the number of collisions among the current carriers.

d) increase in the rate of collisions between the current carriers and the vibrating atoms of the conductor.

24. When three identical cells are connected in parallel, then

a) the current capacity of battery becomes three times the capacity of one cell and output voltage is also tripled.

b) the current capacity of battery remains same and output voltage also remains same as that of one cell.

c) the current capacity of battery remains same and output voltage is tripled.

d) the current capacity of battery becomes three times the capacity of one cell and output voltage remains the same as that of one cell.

25. In a series combination of cells, the effective internal resistance will

a) remain the same

b) decrease

c) increase

d) be half that of the 1st cell

26. If the temperature of metallic conductor increases, the drift velocity of electrons in it will

a) remain same b) increase

c) decrease d) be doubled

28. Semi-conductors have (TC $\rightarrow$ Temperature coefficient)

a) NTC b) PTC

c) constant TC d) infinite TC

29. A strip of copper, another of germanium are cooled from room temperature to 80 K. The resistance of

a) copper strip decreases and that of germanium decreases

b) copper strip decreases and that of germanium increases

c) Both the strip increases

d) copper strip increases and that of germanium decreases

30. The difference in variation of resistance with temperature in a metal and a semi-conductor arises essentially due to the difference in the

a) crystal structure

b) type of bonding

c) variation of scattering mechanism with temperature

d) variation of the number of charge carriers with temperature

31. The terminal voltage of a cell of emf E on short circuiting will be

a) E b) $\frac{E}{2}$

c) 2E d) zero

32. If a battery of emf 2 V with internal resistance one ohm is connected to an external circuit of resistance R across it, then the terminal p.d. becomes 1.5 V. The value of R is

a) 1 Ω b) 1.5 Ω

c) 2 Ω d) 3 Ω

33. A hall is used 5 hours a day for 25 days in a month. It has 6 lamps of 100 W each and 4 fans of 150 W. The total energy consumed for the month is

a) 1500 kWh b) 150 kWh

c) 15 kWh d) 1.5 kWh

34. On a resistor if there are only three colours, the tolerance is

a) ±5% b) ±10%

c) ±15% d) ±20%

35. The emf of a cell is 12 V. When it sends a current of 1 A through an external resistance, the p.d. across the terminals reduces to 10 V. The internal resistance of the cell is

a) 0.10 b) 0.50

c) 10 d) 20

36. The resistivity of Nichrome is 10^{-6} Ω-m. The wire of this material has radius of 0.1 mm with resistance 100 Ω, then the length will be

a) 3.142 m b) 0.3142 m

c) 3.142 cm d) 31.42 m

37. A current of 1.6 A is passed through an electric lamp for half a minute. If the charge on the electron is 1.6×10^{-19} C, the number of electrons passing through it is

a) 1×10^{19} b) 1.5×10^{20}

c) 3×10^{19} d) 3×10^{20}

38. Given a current carrying wire of non-uniform cross-section. Which of the following is constant throughout the length of the wire?

a) current, electric field and drift speed

b) drift speed only

c) current and drift speed

d) current only

39. The internal resistance of a cell of emf 2 V is 0.1 Ω. It is connected to a resistance of 3.9 Ω. The voltage across the cell will be

a) 0.5 V b) 1.5 V

c) 1.95 V d) 2 V

40. Three resistors, 2 Ω, 10 Ω and 3 Ω, are connected in series in an electric circuit. The equivalent resistance of the circuit is

a) 20 Ω b) 14 Ω

c) 11 Ω d) 15 Ω

41. Three resistors, 8 Ω, 4 Ω and 10 Ω connected in parallel as shown in figure,

The equivalent resistance is

a) $\frac{19}{40}\ \Omega$ b) $\frac{40}{19}\ \Omega$

c) $\frac{80}{19}\ \Omega$ d) $\frac{34}{23}\ \Omega$

Answer Keys

1. b)	2. c)	3. a)	4. b)	5. a)	6. a)	7. a)	8. d)	9. c)	10. c)
11. d)	12. c)	13. c)	14. a)	15. c)	16. c)	17. a)	18. d)	19. d)	20. a)
21. d)	22. a)	23. d)	24. d)	25. c)	26. c)	27. b)	28. a)	29. b)	30. d)
31. d)	32. d)	33. b)	34. d)	35. d)	36. a)	37. d)	38. d)	39. c)	40. d)
41. b)									