Ratna Sagar

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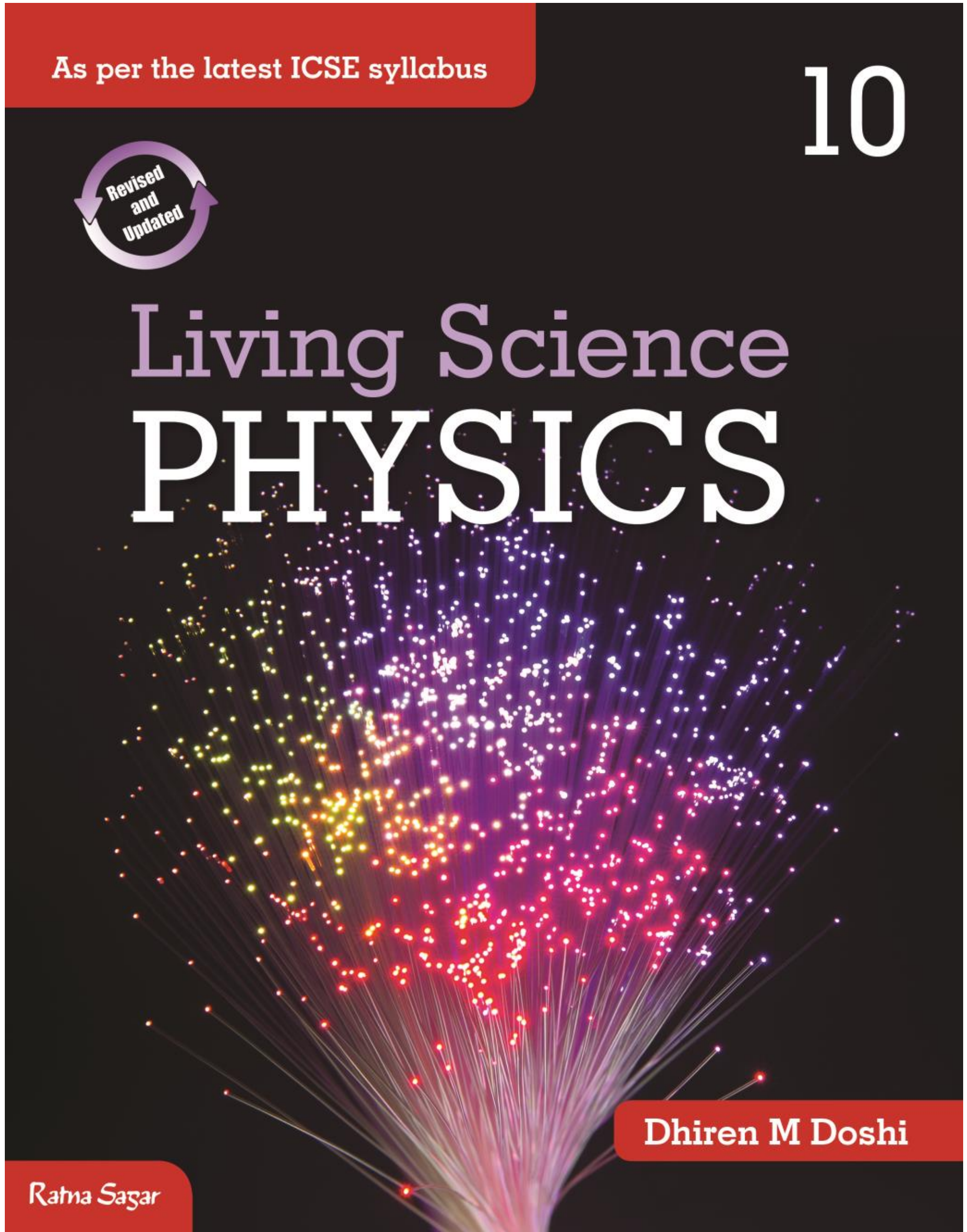
ICSE
Living Science
Physics

Class 10

Chapter-8 Current Electricity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10
Revised and Updated
Living Science
PHYSICS
Dhiren M Doshi
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LEARNING OBJECTIVES

Electricity- An Important Source of Energy

Potential

- ❖**Potential difference**
- ❖**Electric current**
- ❖**Ohm's law**

Electrical Resistance

- ❖**Factors affecting the resistance of a conductor**
- ❖**Experimental verification of Ohm's law: Voltmeter-ammeter method**
- ❖**Superconductors**
- ❖**Specific resistance and resistivity**

Cell and related terms

Combination or grouping of resistors

- ❖**Series and parallel combination of resistors**

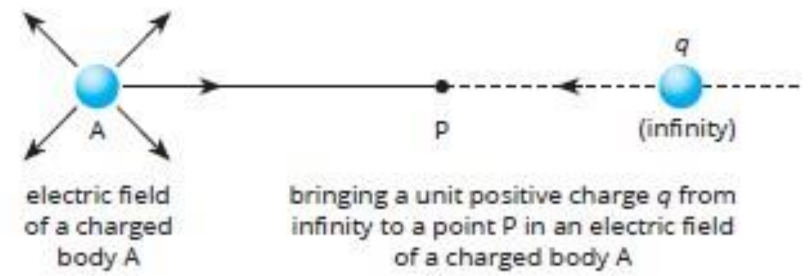
What is Electric Current?

Every atom contains two types of charged particles: protons and electrons. Protons carry a positive (+) charge whereas electrons carry a negative (–) charge.

The flow of electrons in a definite direction is called electric current.

Electric Potential

The electric potential (or simply potential) at a point in an electric field is defined as the amount of work done in bringing a unit positive charge from infinity to that point.



The unit J C^{-1} (joule per coulomb) is called **volt (V)**. So, the SI unit of electric potential is volt which is denoted by V. If 1 joule of work is done in bringing 1 coulomb of positive charge from infinity to a point in an electric field, then the potential at that point is 1 volt.

Potential Difference

The potential difference (p.d.) between two points in an electric field is defined as the amount of work done in moving a unit positive charge from one point to the other point. The SI unit of potential difference is volt and is denoted by The potential difference is measured by an instrument called voltmeter.

Electric Current

The rate of flow of charge in a circuit is called electric current. In other words, it is the amount of charge flowing per second. when 1 coulomb of charge flows through a conductor in 1 second, then the current flowing through it is said to be 1 ampere.

Ohm's Law

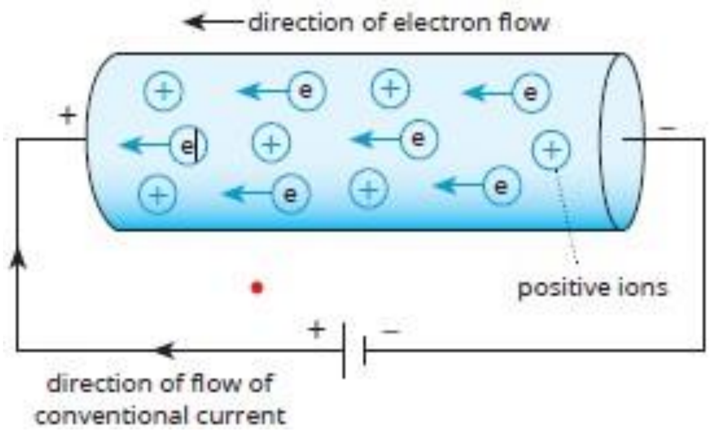
According to Ohm's law, 'The electric current (I) flowing through a conductor is directly proportional to the potential difference (V) across its ends, provided the temperature and other physical conditions of the conductor remain the same, that is $I \propto V$ (At constant temperature and pressure, etc.)

This can also be written as $V \propto I$

or V/I = constant, R where R is a constant of the conductor at a given temperature and is called its **resistance**. The resistance of a conductor is the property of the conductor due to which it resists the flow of electric charges (or flow of electric current). The above equation can also be written as: $R = V/I$

Electric Resistance

The property of a conductor by virtue of which it opposes the flow of electric current through it is called its resistance**.**



The SI unit of resistance is ohm, which is denoted by the symbol Ω called 'ohm'. According to Ohm's law: Resistance (R) = Potential difference (V) / Current (I).

Now, if the potential difference (*V*) is 1 volt and the current (*I*) is 1 ampere, then the resistance (*R*) in the above equation will be 1 ohm. 1 ohm is the resistance of a conductor such that when a potential difference of 1 volt is applied to its ends, a current of 1 ampere flows through it.

Conductance

The reciprocal of resistance of a conductor is called its conductance (*G*), i.e. $G = 1/R$. **The SI unit of conductance is mho** (i.e. ohm spelt backwards). These days it is usual practice to use siemen as the unit of conductance. It is denoted by the symbol S.

Ohmic and non-ohmic resistors

Ohmic resistors: The conductors which obey Ohm's law are called ohmic or linear resistors. Since $I \propto V$, it follows that V/I = a constant. The graph is a straight line passing through the origin. The resistance of an ohmic resistor does not change when the potential difference changes. All metallic conductors such as silver and copper are ohmic resistors.

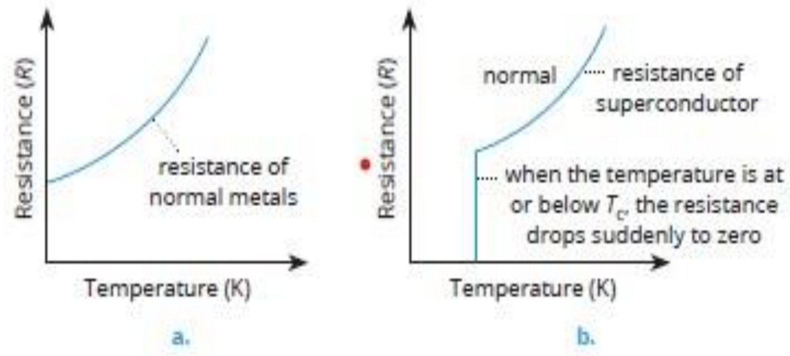
Non-ohmic resistors: The conductors which do not obey Ohm's law are called non-ohmic or non-linear resistors. Vacuum tube, semiconductor diode, transistors, electrolytes and filament lamp are non-ohmic resistors.

The graph plotted for current against potential difference is not a straight line, but it is a curve. The resistance is not constant and is different for different values for *V* and *I*.

Note: The differences between ohmic and non-ohmic resistors are given in Table 8.1 of the book.

Superconductors

The property by virtue of which a conductor shows almost zero resistance at a very low temperature is called superconductivity and the materials which show the property of super-conductivity are called superconductors.



The temperature below which a material becomes a superconductor is called the transition temperature or critical temperature (*T*c). Tungsten, aluminium, mercury and lead are some of the superconductors.

We have $R = \rho\, l/A$ If l = 1 m; A = 1 m2 , then R = r. Hence, specific resistance (or resistivity) of a material is the resistance offered by 1 m length of the wire of the material having area of cross section of 1 m^2 . The SI unit of resistivity is ohm-metre which is written in symbol as Ω m.

Cell and Related Terms

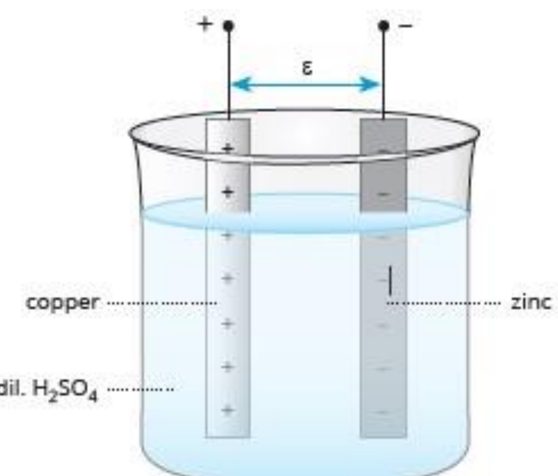
A cell

A cell is a device which provides the necessary potential difference to an electrical circuit to maintain a continuous flow of current in it.

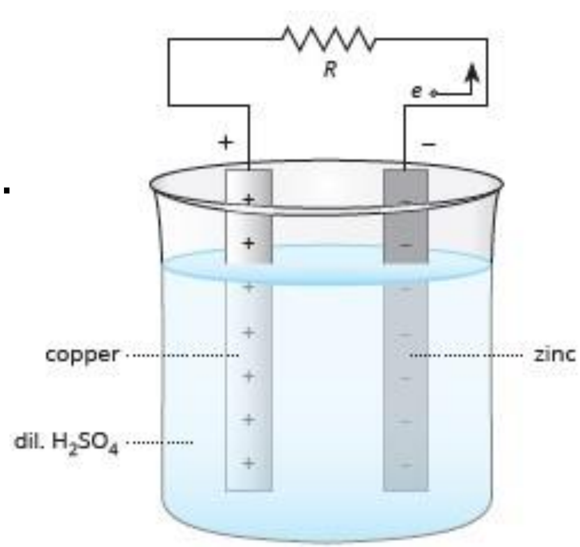
Closed and Open Circuit

When the terminals of the cell are not connected externally to an electrical circuit, no current is drawn from the cell. Such a circuit where no current is drawn from the cell is called an **open circuit**.

When the terminals of the cell are connected externally to an electrical circuit, current is drawn from the cell. Such a circuit where current is drawn from the cell is called a **closed circuit**.



Open circuit.



Closed circuit.

Electromotive force

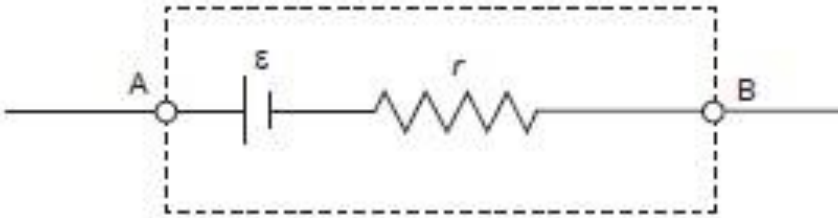
he maximum potential difference between two electrodes or terminals of a cell in an open circuit (i.e. cell delivering no current) is called electromotive force (e.m.f.) of the cell. The electromotive force of a cell can also be defined as the energy supplied by the cell to drive a unit charge around the complete circuit. It is denoted by the symbol e. The SI unit of e.m.f. is volt (V).

Internal Resistance

The resistance offered by the electrolyte of the cell to the flow of current is called internal resistance. It is denoted by the letter '*r*' and its unit is 'ohm' (symbol Ω).

If current *I* is drawn from the cell whose internal resistance is *r*, the voltage drop is *V*, then

$$V = I\,r$$



Representation of a cell

Factors affecting the internal resistance of a cell

1. The surface area of the electrodes in contact with the electrolyte: Larger is the surface area, smaller is the internal resistance, i.e. $r \propto 1/A$

2. The distance between the electrodes: Larger is the distance between the electrodes, greater is the internal resistance, i.e. $r \propto$ distance.

The nature and concentration of the electrolyte: Higher is the concentration of the electrolyte, greater is the internal resistance,

i.e. $r \propto$ concentration of the electrolyte.

4. The temperature of the electrolyte: Higher is the temperature of the electrolyte, lesser is the internal resistance, i.e. $r \propto 1T$

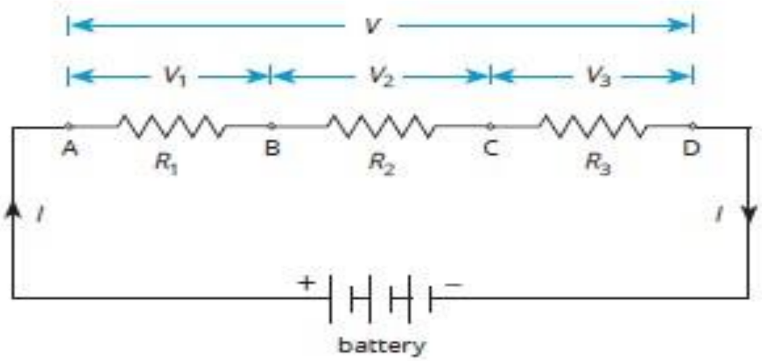
Combination or Grouping of Resistors

Series combination of resistors

Two or more resistors are said to be connected in series if they are connected end to end consecutively in an electric circuit.

When the resistors in a circuit are connected in series

- the current I passing through each resistor is the same.
- each resistor has a different potential difference across its ends. But the sum of the potential differences across all the resistors is equal to the voltage of the battery.



Equivalent Resistance.

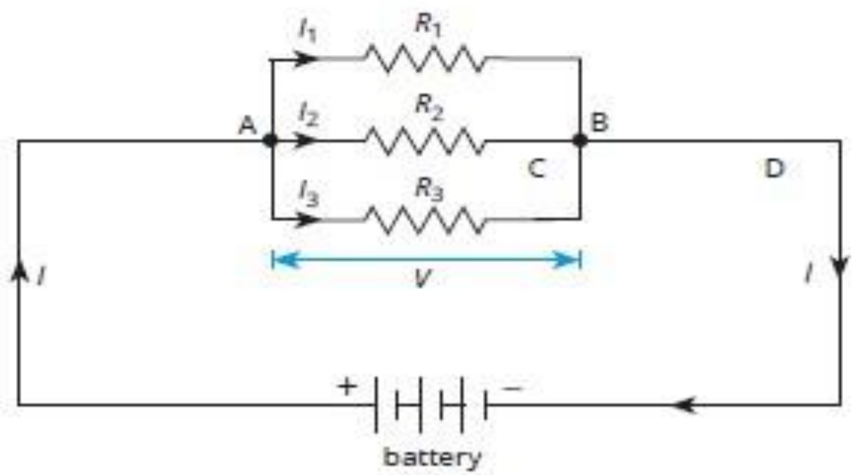
$R_s = R_1 + R_2 + R_3$

Parallel combination of resistors

Two or more resistors are said to be connected in parallel if one end of a resistor is connected to one end of the other resistor and the second end of the first resistor is connected to the second end of the other resistor such that the potential difference across each resistor is the same.

When the resistors in a circuit are connected in parallel

- all the resistors have the same potential across them.
- different amounts of current flow through each resistance. But the sum of currents flowing through all the resistances is equal to the total current flowing in the circuit.



Equivalent Resistance.

$$1/R_P = 1/R_1 + 1/R_2 + 1/R_3$$

Note: In homes, electrical devices are connected in parallel (not in series). Any electrical device can be turned on or off without affecting the functioning of other electrical devices.

SUMMARY

1. **Electric potential:** The electric potential at a point in an electric field is defined as the amount of work done in bringing a unit positive charge from infinity to that point.

2. **Potential difference:** The potential difference between two points in an electric field is defined as the amount of work done in moving a unit positive charge from one point to another point.

3. **Resistance:** The property of a conductor by virtue of which it opposes the flow of electric current through it is called its resistance.

4. **Factors affecting the resistance of a conductor: a.** length of the conductor **b.** area of cross section of the conductor **c.** nature of the material of the conductor **d.** temperature of the conductor.

5. **Ohm's law:** The current flowing through a conductor is directly proportional to the potential difference across its end provided the temperature and other physical conditions of the conductor do not change.

6. **Superconductors:** The property by virtue of which a conductor shows almost zero resistance at a very low temperature is called superconductivity and the materials which show this property are called superconductors. Example: tungsten.

7. **Resistivity:** It is the resistance offered by 1 m length of wire of the material having area of cross section of 1 m^2.

8. **Electromotive force (e.m.f.):** It is the energy supplied by the cell to drive a unit charge around the complete circuit.

9. **Internal resistance:** The resistance offered by the electrolyte of the cell to the flow of current is called internal resistance.

Formulae

1. Electric Potential (*V*) = Work done (*W*) /Charge ( ) *q*
2. Resistance (*R*) = Potential difference (*V*) Current (*I*)
3. Specific resistance or resistivity (ρ) = $(R \times A) / l$
4. Internal resistance (*r*) = $(\varepsilon/V - 1) R$
5. Current (*I*) = $\varepsilon / (R + r)$
6. Drop in potential across the terminal of battery $(\varepsilon - V) = Ir$
7. Equivalent resistance in series, $R = R_1 + R_2 + R_3$
8. Equivalent resistance in parallel, $1/R = 1/R_1 + 1/R_2 + 1/R_3$

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