Unit-2 Current Electricity

Book Back and Additional Question with Answer

1. Define electric current?

The rate of flow of charge through any cross-section of a wire w.r.t. time is called electric current flowing through it.

Electric current $(I) = \frac{q}{t}$. Its SI unit is ampere (A).

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2. **What is the relation between current and frequency?**

If a charge q revolves in a circle with frequency f, the equivalent current,

$$i = qf$$

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3. What is mean by relaxation time?

Relaxation Time (τ)

The time interval between two successive collisions of electrons with the positive ions in the metallic lattice is defined as relaxation time.

$$\tau = \frac{\text{mean free path}}{\text{rms velocity of electrons}} = \frac{\lambda}{v_{rms}}$$

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4. What is mean by drift velocity?

The drift velocity is the average velocity acquired by the electrons inside the conductor when it is subjected to an electric field. Its unit is m s^{-1}

Drift velocity $v_d = \frac{eE\tau}{m} = \frac{eV\tau}{ml}$

where, τ = relaxation time,
e = charge on electron,
E = electric field intensity,
l = length of the conductor,
V = potential difference across the ends of the conductor
and m = mass of the electron.

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5. **What is a relation between current and drift velocity?**

Relation between electric current and drift velocity is given by

$$v_d = \frac{I}{An\ e}$$

6. **Define current density give SI unit and dimensional formula?**

The electric current flowing per unit area of cross-section of a conductor is called current density.

$$\text{Current density } (J) = \frac{I}{A} = nev_d$$

Its SI unit is ampere metre^{-2} (Am^{-2}) and dimensional formula is [AT^{-2}]. It is a vector quantity ~~and its direction is in the direction of~~

7. **Define Mobility give its SI units and dimensional formula**

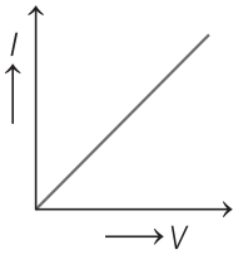
Mobility is defined as the magnitude of the drift velocity per unit electric field. Its unit is $m^2\ V^{-1}\ s^{-1}$.

$$\mu = \frac{|\vec{v}_d|}{|\vec{E}|}$$

8. **What is the Ohmic conductors?**

Those conductors which obey Ohm's law, are called ohmic conductors, *e.g.* all metallic conductors are ohmic conductor.

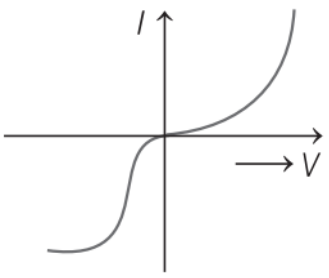
For ohmic conductors *V-I* graph is a straight line.



9. **What is the non ohmic conductors?**

Those conductors which do not obey Ohm's law, are called non-ohmic conductors, *e.g.* diode valve, triode valve, transistor , vacuum tubes etc.

For non-ohmic conductors *V-I* graph is not a straight line.



10. **Define electrical resistance give its SI units and dimensional formula?**

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The obstruction offered by any conductor in the path of flow of current is called its electrical resistance.

Electrical resistance, $R = \frac{V}{I}$

Its SI unit is ohm (Ω) and its dimensional formula is $[ML^2T^{-3}A^{-2}]$.

Electrical resistance of a conductor, $R = \frac{\rho l}{A}$

where, l = length of the conductor, A = cross-section area
and ρ = resistivity of the material of the conductor.

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11. What is Resistivity

Resistivity of a material of a conductor is given by

$$\rho = \frac{m}{ne^2\tau}$$

where, n = number of free electrons per unit volume.

Resistivity is low for metals, more for semiconductors and very high for alloys like nichrome, constantan etc.

Resistivity of a material depend on temperature and nature of the material. It is independent of dimensions of the conductor, *i.e.* length, area of cross-section etc.

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12. Define temperature coefficient of resistivity. Give its unit.

Temperature coefficient of resistivity is defined as the ratio of increase in resistivity per degree rise in temperature to its resistivity at T_o. Its unit is per ^0C

$$\alpha = \frac{\rho_T - \rho_0}{\rho_0 (T - T_0)} = \frac{\Delta\rho}{\rho_0 \Delta T}$$

$$or \qquad \alpha = \frac{R_T - R_0}{R_0 (T - T_0)} = \frac{\Delta R}{R_0 \Delta T}$$

Where,

ρ_t , R_t – Resistivity and resistance at T^0 C respectively.

ρ_0, R_0 – Resistivity and resistance at T_0 ^{0}C respectively.

- **For conductors**,the resistivity increases with increase in temperature. So α is positive.
- **For Semiconductors**,the resistivity decreases with increase in temperature. So α is negative.

13. **Note**

In magnetic field, the resistivity of metals increases. But resistivity of ferromagnetic materials such as iron, nickel, cobalt etc decreases in magnetic field.

14. What is electrical conductivity

The reciprocal of resistivity is called electrical conductivity.

$$\text{Electrical conductivity } (\sigma) = \frac{1}{\rho} = \frac{l}{RA} = \frac{ne^2\tau}{m}$$

Its SI units is ohm^{-1}m^{-1} or mho m^{-1} or siemen m^{-1}.

Relation between current density (J) and electrical conductivity (σ) is given by $J = \sigma E$

where, E = electric field intensity.

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15. What is meant by free electrons?

Atoms in metals have one or more electrons which are loosely bound to the nucleus. These electrons are called free electrons and can be easily detached from the atoms.

16. What is superconductivity?

Superconductors

When few metals are cooled, then below a certain critical temperature their electrical resistance suddenly becomes zero. In this state, these substances are called **superconductors** and this phenomena is called **superconductivity.**

Mercury become superconductor at 4.2 K, lead at 7.25 K and niobium at 9.2 K.

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17. What is electric cell give their types

An electric cell is a device which converts chemical energy into electrical energy.

Electric cells are of two types

(i) **Primary Cells** Primary cells cannot be charged again. Voltaic, Daniel and Leclanche cells are primary cells.

(ii) **Secondary Cells** Secondary cells can be charged again and again. Acid and alkali accumulators are secondary cells.

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18. What is emf of a cell

The energy given by a cell in flowing unit positive charge throughout the circuit completely one time is equal to the emf of a cell.

Emf of a cell $(e) = \frac{W}{q}$.

Its SI unit is volt.

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19. Terminal potential difference of a cell

The energy given by a cell in flowing unit positive charge through the outer circuit one time from one terminal of the cell to the other terminal of the cell.

Its SI unit is also volt. It is always less than the emf of a cell.

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20. What is internal resistance of a cell how to change it

The obstruction offered by the electrolyte of a cell in the path of electric current is called internal resistance (r) of the cell. Internal resistance of a cell

(i) increases with increase in concentration of the electrolyte.

(ii) increases with increase in distance between the electrodes.

(iii) decreases with increase in area of electrodes dipped in electrolyte.

21. Define thermocouple

If two wires of different metals are joined at their ends so as to form two junctions, then the resulting arrangement is known as thermocouple.

22. What are the Uses of thermocouple

(a) Thermometer to measure temperature.

(b) Thermoelectric current-meter to measure current.

(c) Thermoelectric generator.

(d) Thermoelectric refrigerator.

23. What is a conductor

The substances which have an abundance of these free electrons are called conductors.

24. **What are the direction of electric charges moving in electric circuit**

Positive charge flows from region of higher electric potential to region of lower electric potential and negative charge flows from region of lower electric potential to region of higher electric potential

25. What is the uses of Battery or electric cell

Battery or electric cell simply creates potential difference across the conductor.

26. Define Electric Current

The electric current in a conductor is defined as the rate of flow of charges through a given cross-sectional area A.

If a net charge Q passes through any cross section of a conductor in time t, then the current is defined as

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

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27. Define instantaneous current

The instantaneous current I is defined as the limit of the average current, as $\Delta t \to 0$

$$I = \lim_{\Delta t \to 0} \frac{\Delta Q}{\Delta t} = \frac{dQ}{dt}$$

The SI unit of current is the **ampere** (A)

28. Define one Ampere

1A of current is equivalent to 1 coulomb of charge passing through a perpendicular cross section in a conductor in one second. The electric current is a scalar quantity.

29. Define Conventional Current

By convention, this flow in the circuit should be from the positive terminal of the battery to the negative terminal. This current is called the conventional current or simply current

30. The drift velocity of electrons in the wire is 10^{-4} m s^{-1} then how electric bulbs glow as soon as we switch on the battery?

- When battery is switched on, the electrons begin to move away from the negative terminal of the battery and this electron exerts force on the nearby electrons.
- This process creates a propagating influence (electric field) that travels through the wire at the speed of light.
- In other words, the energy is transported from the battery to bulb at the speed of light through propagating influence (electric field).
- Due to this reason, the bulb glows as soon as the battery is switched on.

31. Why current density is a vector but current is a scalar?

In general, the current I is defined as the scalar product of the current density and area vector in which the charges cross.

$$I = \vec{J} \cdot \vec{A}$$

32. What is resistance?

The resistance is the ratio of potential difference across the given conductor to the current passing through the conductor.

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

The SI unit of resistance is ohm (Ω).

33. Define electrical resistivity (Ω). Give its unit.

The electrical resistivity of a material is defined as the resistance offered to current flow by a conductor of unit length having unit area of cross section. Its unit is ohm-metre (Ω m).

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

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34. How to Materials are classified as conductors, insulators and semiconductors.

Based on the resistivity, the **conductors** have lowest resistivity, **insulators** have highest resistivity and **semiconductors** have resistivity greater than conductors but less than insulat

35. **What kind of connections are used in house hold appliances why?**

House hold appliances are always connected in parallel so that even if one is switched off, the other devices could function properly.

36. What is the temperature coefficient of resistivity?

It is defined as the ratio of increase in resistivity per degree rise in temperature to its resistivity at To.

$$\therefore \alpha = \frac{\rho_T - \rho_\circ}{\rho_\circ (T - T_\circ)} = \frac{\Delta\rho}{\rho_\circ \Delta T}$$

37. Resistivity of materials depends on

The resistivity of materials is

i) inversely proportional to the number density (n) of the electrons

ii) inversely proportional to the average time between the collisions (τ).

38. Define critical temperature

The resistance of certain materials become zero below certain temperature *Tc*. This temperature is known as critical temperature or transition temperature.

39. **What is super conductors**

The resistance of certain materials become zero below certain temperature *Tc*. This temperature is known as critical temperature or transition temperature. The materials which exhibit this property are known as superconductors.

40. **What is electric power**

The electrical power P is the rate at which the electrical potential energy is delivered

$$P = \frac{dU}{dt} = \frac{(V.dQ)}{dt} = V\frac{dQ}{dt} \qquad P = VI$$

41. What is electric cell

An electric cell converts chemical energy into electrical energy to produce electricity. It contains two electrodes (carbon and zinc) immersed in an electrolyte (sulphuric acid)

42. When the car engine is started with headlights turned on, they sometimes become dim Why?

This is due to the internal resistance of the car battery

43. State Kirchhoff's Current rule

It states that the algebraic sum of the currents at any junction of a circuit is zero.

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44. State Kirchhoff's Voltage rule

It states that in a closed circuit the algebraic sum of the products of the current and resistance of each part of the circuit is equal to the total emf included in the circuit.

45. What is Joule's heating effect?

When current flows through a resistor, some of the electrical energy delivered to the resistor is converted into heat energy and it is dissipated. This heating effect of current is known as Joule's heating effect.

46. **State joule's law of heating**

It states that the heat developed in an electrical circuit due to the flow of current varies directly as

a. the square of the current
b. the resistance of the circuit and
c. the time of flow.

47. **Nichrome is used in Electric heaters why?**

The heating elements are made of nichrome, an alloy of nickel and chromium. Nichrome has a high specific resistance and can be heated to very high temperatures without oxidation.

48. Why electric fuse wire is used in electric appliances

- It is a short length of a wire made of a low melting point material.
- It melts and breaks the circuit if current exceeds a certain value.
- An alloy of lead - tin is used for fuses when current rating is below 15 A and when current rating is above 15 A, copper fuse wires are used.

49. **What is thermoelectric effect**

Conversion of temperature differences into electrical voltage and vice versa is known as thermoelectric effect.

50. What is seebeck effect

Seebeck discovered that in a closed circuit consisting of two dissimilar metals, when the junctions are maintained at different temperatures an emf (potential difference) is developed. The current that flows due to the emf developed is called thermoelectric current.

51. **What are the Applications of Seebeck effect?**

- Seebeck effect is used in thermoelectric generators (Seebeck generators). These thermoelectric generators are used in power plants to convert waste heat into electricity
- This effect is utilized in automobiles as automotive thermoelectric generators for increasing fuel efficiency.
- Seebeck effect is used in thermocouples and thermopiles to measure the temperature difference between the two objects.

52. **What is Peltier effect**

When an electric current is passed through a circuit of a thermocouple, heat is evolved at one junction and absorbed at the other junction. This is known as Peltier effect.

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53. What is Thomson effect

If two points in a conductor are at different temperatures, the density of electrons at these points will differ and as a result the potential difference is created between these points. Thomson effect is also reversible.

54. Difference between Drift velocity and mobility

S. No.	Drift velocity	Mobility
1.	The average velocity acquired by the electrons inside the conductor when it is subjected to an electric field.	The magnitude of the drift velocity per unit electric field.
2.	Its unit is m s^{-1}.	Its unit is $m^2 V^{-1} s^{-1}$.
3.	It is directly proportional to electric field.	It is constant for particular material of the conductor.

55. State microscopic form of Ohm's law.

The current density of the conductor is directly proportional to the applied electric field.

$$\vec{J} = \sigma \vec{E}$$

56. State macroscopic form of Ohm's law.

The current flowing through the conductor is directly proportional to the potential difference between the ends of the conductor. V = IR

57. What is thermistor?

A semiconductor with a negative temperature coefficient of resistance is called a thermistor.

58. What is conductivity? Give its unit.

The reciprocal of resistivity is called conductivity. Its unit is ohm^{-1} m^{-1}.

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

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59. What is electric power? Give its unit.

The electrical power P is the rate at which the electrical potential energy is delivered. Its unit is watt (W).

$$P = \frac{dU}{dt} = VI = I^2R = \frac{V^2}{R}$$

60. Define 1 watt.

1 watt is defined as electrical potential energy of 1 joule delivered per second. i.e. 1W $=1Js^{-1}$.

61. What is an electric energy?

An electrical energy is the work done by the moving streams of the electrons or charges.

- ***Electrical energy = Electric Power × time***
- The practical unit of electrical energy is kilowat hour(**kWh**).
- 1 kWh = 1unit = 1000 Wh = 3.6 X 10^6 J.

62. What do you mean by internal resistance of a cell?

The resistance offered by the electrolyte to the flow of charges within the battery is called internal resistance of the battery.

63. What is Potentiometer?

Potentiometer is a device, which is used for the accurate measurement of potential differences, current and resistances.

64. State the principle of potentiometer.

The emf of the cell is directly proportional to the balancing length of the potentiometer wire. i.e. $\xi \propto l$.

65. What is positive Thomson effect?

In some metals, heat is transferred due to the current flow in the direction of the current. It is called positive Thomson effect. Ex: Cu, Ag, zn, and cd.

66. What is negative Thomson effect?

In some metals, heat is transferred due to the current flow in the direction opposite to the current. It is called negative Thomson effect. Ex: Fe, pt, Ni, Co, and Hg.

Distinguish electric energy and electric power.

Electric Energy	Electric Power
Work has to be done to move the charge from one end to other end of the conductor and this work done is called electric energy. $dW = dU = VdQ$	➢ The rate at which the electrical potential energy is delivered is called electric power. $P = \frac{dU}{dt} = VI$
Its S.I unit is joule (J)	➢ Its S.I unit is watt (W)
Its practical unit is kilowatt hour (kWh) $1kWh = 3.6 \times 10^6\ J$	➢ Its practical unit is horse power (HP) $1\ HP = 746\ W$

67.

68. **Note**

Write down the various equations for power.

The electric power is given by, $P = VI$

By Ohm's law, $V = IR$ and hence $P = I^2R$

Also, $I = V/R$ and hence, $P = \frac{V^2}{R}$

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69. **What is called conventional current?**

By convention, this flow in the circuit should b from the positive terminal of the battery to the negative terminal. This is called the conventional current or simply current. It is in the direction in which a positive test charge would move.

70. **What are called free electrons and positive ions?**

- Any material is made up of neutral atoms with equal number of electrons and protons. If the outermost electrons leave the atoms, they become free electrons and are responsible for electric current.
- The atoms after losing their outer most electrons will have more positive charges and hence are called positive ions. They will not move freely and hence the positive ions will not give rise to current.

What are the factors that the resistance depend on?

The resistance of the conductor is,

1) directly proportional to its length (l)
2) inversely proportional to its area of cross section (A)

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

71. where, $\sigma \rightarrow$ conductivity of the conductor, $\rho \rightarrow$ resistivity of the conductor

Repairing the electrical connection with the wet skin is always dangerous. Why?

The human body contains a large amount of water which has low resistance of around 200 Ω and the dry skin has high resistance of 500 k Ω.

But when the skin is wet, the resistance is reduced to 1000 Ω.

By Ohm's law $[R = \frac{V}{I}]$ if resistance decreases, current increases.

72. Hence repairing electric connection with wet skin is dangerous.

Define electromotive force.

The amount of work a battery or cell does to move a certain amount of charge around the circuit is called as ***electromotive force (ξ)***. Its unit is volt (V)

73. The emf of a battery or a cell is the voltage provided by the battery when no current flows in the external circuit.

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74. **Distinguish between Peltier effect and Joule's effect.**

Peltier effect	Joule's effect
Both heat liberated and absorbed occur	➢ Heat liberated only occur
Occurs at junctions	➢ Occurs all along the conductor
Reversible effect	➢ Irreversible effect

----------All the Best----------

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