REVIEW QUESTIONS

14.1 **Define and explain the term electric current.**
See Question no. 1

14.2 **What is the difference between electronic current and conventional current?**

Ans. Electronic current flows due to the motion of electrons (negative charges) from the negative terminal of the battery to the positive terminal. Whereas conventional current flows due to the motion of positive charges form the positive terminal of the battery to the negative terminal.

14.3 **What do we mean by the term e.m.f? Is it really a force? Explain.**
See Question no. 6

14.4 **How can we differentiate between e.m.f and potential difference?**
The electromotive force (emf) of a battery or a cell is the total energy supplied in driving one coulomb of charge round a complete circuit in which the cell is connected. The complete circuit includes the cell itself and an external circuit connected to the terminals. Whereas the potential difference determines the energy required between any two points of the circuit, in moving a charge form one point to another.

14.5 **Explain Ohm's law. What are its limitations?**

Ans: See Question no. 8

14.6 **Define resistance and its units.**

Ans: See Question no. 10

14.7 **What is the difference between conductors and insulators?**

Ans: See Question no. 12

14.8 **Explain the energy dissipation in a resistance. What is Joule's law?**

Ans: See Question no. 15

14.9 **What is difference between D.C. and A.C?**

Ans: See Question no. 18

14.10 **Discuss the main features of parallel combination of resistors.**

Ans: See Question no. 14

14.11 **Determine the equivalent resistance of series combination of resistors.**

Ans: See Question no. 13

14.12 **The voltage chosen for the transmission of electrical power over large distances is many times greater then the voltage of the domestic supply. State two reasons why electrical power is transmitted at high voltage.**

Ans: The reasons for transmission of high voltage are as under:

1. **Sending power at high voltage would reduce the power loss in the form of heat** dissipation i.e. I^2 Rt. For same power, high voltage means lower current and hence less power loss
2. **Sending power at high voltage means low current. It means we need thinner wires** and also less number of repeater step- up transformers to send power over long destinations.

14.13 **Why is the voltage used for the domestic supply much lower than the voltage at which the power is transmitted?**

Ans. Domestic appliances operate on low voltage because high voltage can damage these instruments. High voltage can also be dangerous for users as it can cause electric shock. It may also damage property and other valuables as a result of some serious electric shock.

14.14 Describe briefly the hazards of household electricity?

Ans: See Question no. 21

14.15 Describe four safety measures that should be taken in connection with the household circuit.

Ans: See Question No. 22, 23, 24,25

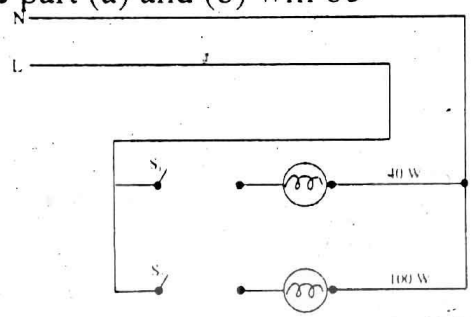
14.16 Design a circuit diagram for a study room that needs the following equipment in parallel.

(a) One 100 W lamp operated by one switch.

(b) One reading lamp fitted with a 40 W bulb which can be switched ON and OFF from two points.

(c) What is the advantage of connecting the equipment in parallel instead of in series combination.

Ans. The circuit diagram of the part (a) and (b) will be



(c) In a parallel circuit voltage remains the same (240V) across each equipment. On the other hand, I series circuit voltage across each equipment will not be 240V, but the sum of voltages will be 240 V. Therefore, in series circuit, the equipments will not work.

CONCEPTUAL QUESTIONS

14.1 Why in conductors charge is transferred by free electrons rather than by positive charge?

Ans. Heavy positively charged protons in conductors (metals) are bound in the nuclei of atoms. Therefore, they are not free to move inside the conductors. Electrons present at the larger distance form the nuclei of atoms of conductor are loosely bound. These electrons are called free electrons which can move freely inside the conductor and are means of charge transfer in conductors.

14.2 What is the difference between a cell and a battery?

Ans. Cells convert chemical energy into electrical energy. A cell consists of two metal electrodes (anode and cathode) dipped into an electrolyte. Groups of cells are known as batteries. Battery stores larger energy as compared to a single cell.

14.3 Can current flow in a circuit without potential difference?

Ans. According to Ohm's law ($v = IR$), current passing through a conductor is directly proportional to the potential difference across the two ends of the conductor. Hence, when potential difference in a circuit is zero no current will flow through it.

14.4 Two points on an object are at different electric potential. Does charge necessarily flow between them?

Ans. Consider two points A and B on an object having electric potential V_a and V_b. The charge will flow only when the two points are at different potential. It means the charge will flow when potential at one point is higher than the potential at the other point. Thus, charge flows due to the difference of electric potential.

14.5 **In order to measure current in a circuit, why ammeter is always connected in series?**

Ans. In order to measure current, ammeter is always connected in series with the circuit so that all the current to be measured must flow through it (due to its low resistance) . If it is connected in parallel, we cannot measure the actual current flowing through the circuit as some current will flow along the other parallel path.

14.6 **In order to measure voltage in a circuit, voltmeter is always connected in parallel. Discuss.**

Ans. In order to measure voltage in a circuit, voltmeter is always connected in parallel with the circuit. In this way, voltmeter does not disturb the current and hence the voltage of the circuit. Due to high resistance of voltmeter, no current passes through it and hence voltage of the circuit remains unaffected.

14.7 **How many watt-hours are there in 1000 joules?**

Ans. As we know,

1 watt × 3600s = 1 watt-hour

3600 Ws = 1 watt-hours

3600 Joules = 1 watt-hours

$$1 \text{ joules} = \frac{1}{3600} \text{ watt-hours}$$

$$1000 \text{ joules} = \frac{1}{3600} \times 1000 \text{ watt-hours}$$

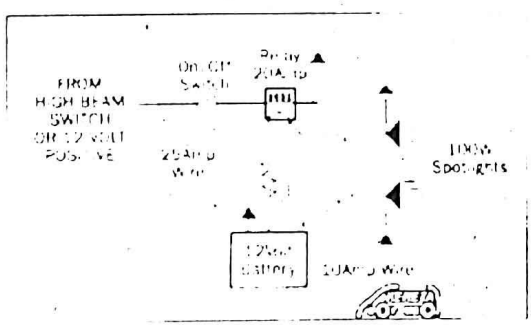
1000 joules = 0.28 watt –hours

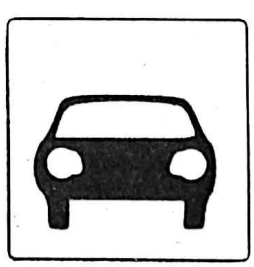
Hence there are 28×10^{-2} watt-hours in 100 joules

14.7 **From your experience in watching cars on the roads at night, are automobile headlamps connected in series or in parallel?**

Ans. Head lamps of automobiles are connected in parallel because of the following reasons

- The potential difference between headlamps remains same. (Both have same brightness)
- If one head-lamp is out of order the other lamps still glow. Also we can turn ON or OFF any individual head lamp independently, which is only possible if they are connected in parallel.





14.9 **A certain flash-light can use a 10 ohm bulb or a 5 ohm bulb. Which bulb should be used to get the brighter light? Which bulb will discharge the battery first?**

Ans. To get the brighter light and discharge the battery first, we have to use bulbs of resistance 5 ohm. Lower resistance of bulb means, larger current will pass through the filament of the bulb and hence it will flow more brightly as compared to that of 10 Ohm bulb. When larger current passes through the circuit, battery will be discharged quickly.

14.10 It is impracticable to connect an electric bulb and an electric heater in series. Why?

Ans. When appliances are connected in series, total resistance of circuit increases. This decreases the current and hence the power through each appliance. In order to avoid this loss of current and power, through bulb and heater, they are connected in parallel.

14.11 Does a fuse in a circuit control, the potential difference or the current?

Ans. Fuse in a circuit is used to control the current in the circuit. When current exceeds the limited value as allowed by the fuse, it burns out, stops the current and beaks the circuit.

INFORMATION BASED QUESTIONS AND THEIR SOLUTION

Quick Quiz (Page 97)

Q.1 How long does it take a current of 10mA to deliver 30 C of charge?

Ans. Solution Given that

$I = 10\ mA = 10 \times 10^{-3}\ A$, $Q = 30C$

Using the formula

$$I = \frac{Q}{t} \text{ or } t = \frac{Q}{I} = \frac{30}{10 \times 10^{-3}} = 3 \times 10^{-3}\ s$$

Quick Quiz (Page 106)

Q.2 Which metal is used as the filament of an electric bulb? Explain with reason.

Ans. A metal of high resistance (such as tungsten) is used as the filament of electric bulb. When electrons pass throught the filament, they feel larger resistance due to witch filament is heated and starts glowing.

Point to Ponder (Page 107)

Q.3 A bird can sit harmlessly on high tension wire. But it must not reach and grab neighboring wire. Do you know why?

Ans. A bird can sit harmlessly on high tension wire as no current passes through its body, since the potential of the wire is constant. However, if the bird grabs the neighbouring wire, then due to potential difference of two wires, current will flow through the body of the bird and con be fatal

Brain Teaser (Page 107)

Q.4 Connect a battery to a small 2.5V light bulb and observe the brightness of the bulb. Now add another light bulb in series with the first bulb. Observe the relative brightness of the bulbs compared to when only one bulb was lit. Pepeat the process with two or three additional bulbs in series. Using ohm's law. Explain what happened to the brightness of each bulb.

Ans. Connecting 2nd bulb in series with the 1st one, it decreases the brightness of two bulbs. Adding additional bulbs in series with these two bulbs will further reduce the glow and brightness of each bulb. In fact, adding more bulbs in series circuit increases the resistance of the circuit. Hence, according to ohm's law (V = IR), current through each bulb will be reduced which in turn decreases the brightness of eac bulb.

Connecting 2nd bulb in parallel with 1st bulb, the battery of 2.5V will not affect the brightness of the 1st bulb. Rather, both bulbs wil glow with same brightness as in parallel circuit, both bulbs have the sam e potential difference. Adding more bulbs wil also not affect the birthness of each bulb. How ever, brightness of each bulb in parallel circuit is large as compared to the brightness of bulbs in series circuit.

Self Assessment (Page 112)

Q.5 A ligh bulb is switched on for 40s. If the electrical energy consumed by the bulb during this time is 2400 J, find the power of the bulb

Ans. Given that,

$t = 40s$, $w = 2400\ J$ and $P = ?$

Using formula:

$$\text{Power} = \frac{\text{Electric energy}}{\text{time}}$$

$$P = \frac{2400\,J}{40\,s} = 60Js^{-1}\ 60W$$

Hence, power of the bulb is 60watt.

EXERCISE

14.1 Choose the correct answer form the following choices:

(i) **An electric current in conductors in due to the flow of**

(a) positive ions (b) negative ions (c) positive charges (d) free electrons

(ii) **What is the voltage across a 6 Ω resistor when 3A of current passes through it?**

(a) 2V (b) 9V (c) 18V (d) 36V

(iii) **What happens to the intensity or the brightness of the lamps connected in series as more** and more lamps are added?

(a) increases (b) decreases (c) remains the same (d) cannot be predicted

(iv) **Why should household appliances be connected in parallel with the voltage source?**

(a) to increase the resistance of the circuit

(b) to decrease the resistance of the circuit

(c) to provide each appliance the same voltage as the power source

(d) to provide each appliance the same current as the power source

(v) **Electric potential and e.m.f**

(a) are the same terms (b) are the different terms

(c) have different units (d) both (b) and (c)

(vi) **When we double the voltage in a simple electric circuit, we double the**

(a) current (b) power (c) resistance (d) both (a) and (b)

(vii) **If we double both the current and the voltage in a circuit while keeping its resistance** constant, the power

(a) remains unchanged (b) halves

(c) doubles (d) changes/replace

(viii) **What is the power rating of a lamp connected to a 12V source when it carries a current of 2.5A?**

(a) 4.8 W (b) 14.5 W (c) 30 W (d) 60 W

(ix) **The combined resistance of two identical resistors, connected in series is 8Ω. Their combined resistance in a parallel arrangement will be**

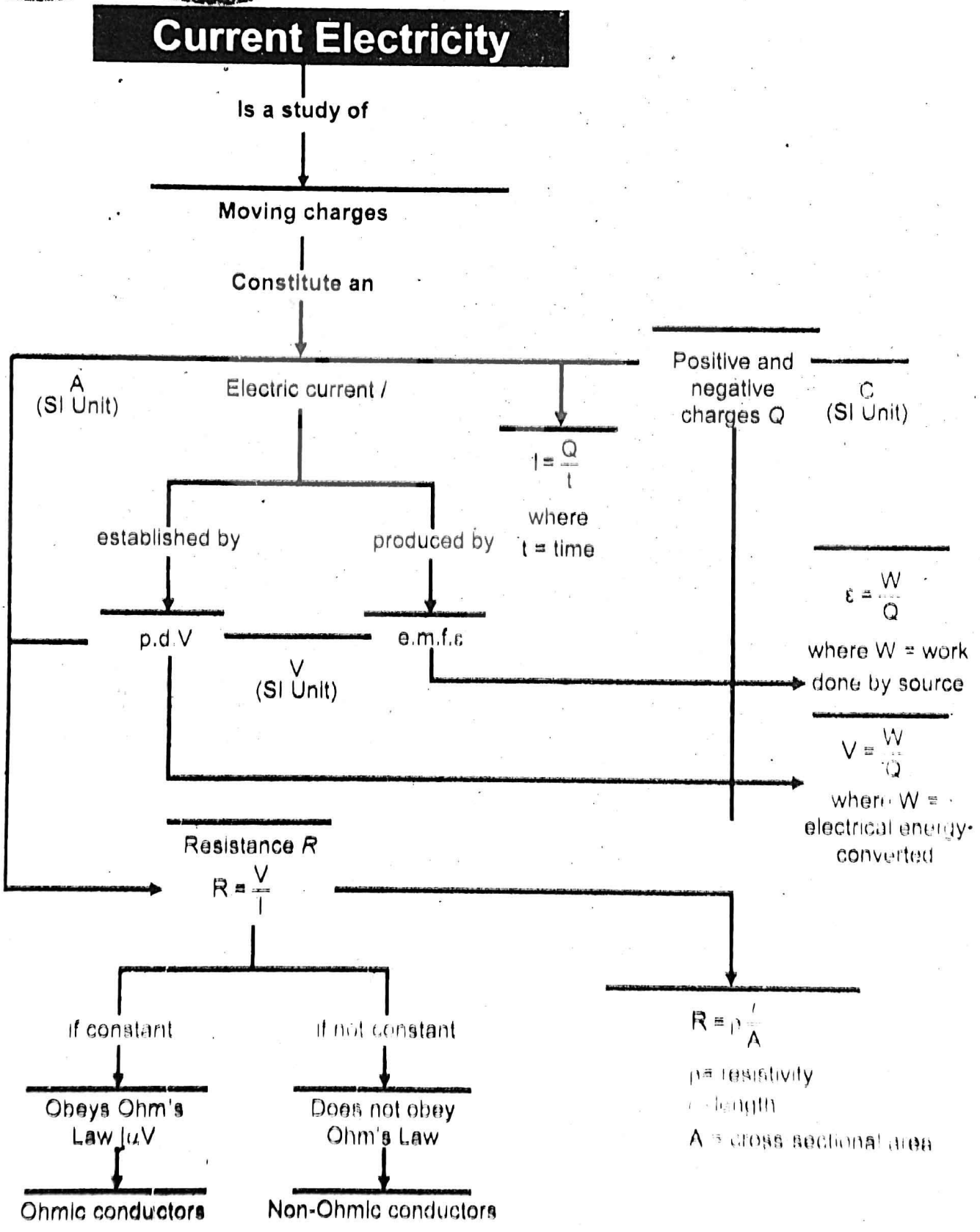
(a) 2Ω (b) 4Ω (c) 8Ω (d) 12 Ω

Q	Ans	Q	Ans	Q	Ans	Q	Ans
1.	d	2.	c	3.	b	4.	c
5.	a	6.	d	7.	c	8.	c
9.	a						

CHAPTER 14

CURRENT ELECTRICITY

CONCEPT MAP



Practical Electricity

deals with the use of electric in

- Electric heating
- Electric lighting
- Electric motors

consumes power and energy given by

$P = IV$ where
P = power (W)
I = current (A)
V = potential difference (V)

$E = Pt$ where
E = energy (J)
P = power (W)
t = times (s)

Or expressed in units of electricity usage

Kilowatt hours
kWh or
Measurements
of electricity

can cause electric shocks of fires in situations such as

- Damaged insulation
- Overheating of cables
- Damp conditions

which can be prevented by using

Safety measure

such as

requires safety measures such as

1. Fuses or circuit breakers
2. Switches fitted on the live wire
3. Earthing
4. Double insulation

TOPICAL MULTIPLE CHOICE QUESTIONS

14.1 Electric Current

(1) **In metals, current is produced only due to the flow of**
(a) Protons (b) Electrons (c) Free electrons (d) Neutrons

(2) **In electrolyte, current is produced due to the flow of**
(a) Positive charge (b) Negative charges
(c) Both positive and negative charges (d) None of these

(3) **The rate of flow of electric charge through any cross-sectional area is called**
(a) Electrostatics (b) Electric current (c) e.m.f (d) Voltage

(4) **The SI unit of electric current is**
(a) Volt (b) Farad (c) Capacitance (d) Ampere

(5) **The equivalent current of positive charges which flows through a conductor is known as**
(a) Electronic current (b) Conventional current (c) Electrostatic (d) Ampere

(6) **The current due to negative charges and an equivalent current due to positive charges always flow in the**
(a) Opposite direction (b) Same direction
(c) Perpendicular to each other (d) None of these

(7) **In electricity, we assume that electric current is always due to the flow of**
(a) Negative charges (b) Neutral particles
(c) Positive charges (d) Both negative and positive charges

(8) **The conventional current of positive charges flows from a point of**
(a) Higher potential to a point of lower potential (b) Lower potential to a point of higher potential
(c) Lower potential to a point of lower potential (d) Higher potential to a point of higher potential

(9) **The current constituted by negative charges flows from a point of**
(a) Higher potential to a point of a lower potential
(b) Lower potential to a point of higher potential
(c) Lower potential to a point of lower potential
(d) Higher potential to a point of higher potential

(10) **When we connect a battery across a conductor, the energy is provided to the charges in the conductor by the**
(a) Magnetic field produced in the conductor
(b) Electromagnetic field produced in the conductor
(c) Electric field produced in the conductor
(d) None of the above

(11) **Energy is produced to transfer the electrons from positive terminal of the battery to the negative terminal by the**
(a) Electrical process (b) Chemical process (c) Thermal process (d) Magnetic process

(12) **The current through a metallic conductor is due to the motion of**
(a) Protons (b) Neutrons (c) Electrons (d) Free electrons

(13) **In liquids and gases, the current is due to the motion of**
(a) Negative charges (b) Positive charges
(c) Both negative and positive charges (d) Neutral particles

(14) **Free electrons are**
(a) Tightly bound (b) Fixed (c) Loosely bound (d) Tightly fixed

(15) **The direction of conventional current flowing in a circuit is**
(a) from negative to positive in the external circuit and from positive to negative within the source of potential difference (battery)
(b) from positive to negative in the external circuit and from negative to positive within the source of P.D.
(c) From positive to negative throughout the circuit.
(d) From negative to positive throughout the circuit.

(16) **The direction of the electronic current in the closed circuit is**
(a) along the flow of electrons
(b) opposite to the flow of electrons
(c) from positive to negative in the external circuit
(d) along the direction of positive charges.

(17) **If a charge 'Q' flows through any cross-section of the conductor in time 't' second, the current 'I' is given by**
(a) $I = Qt$ (b) $I = Q/t$ (c) $I = t/Q$ (d) $I = Q2/t$

(18) **One coulomb per second is equal to**
(a) One volt (b) One Ampere (c) One watt (d) One Ohm

(19) **Which of the following represents an electric current?**
(a) Erg C^{-1} (b) Cs^{-1} (c) $J S^{-1}$ (d) Dyne S^{-1}

(20) **If 1 ampere current flows through 2m long conductor, the charge flow through this in 1hour will be**
(a) 3600 C (b) 7200 C (c) 1C (d) 2C

(21) **Batteries convert**
(a) electrical energy into heat energy (b) electrical energy into chemical energy
(c) chemical energy into electrical energy (d) heat energy into chemical energy

(22) **The electronic current is due to the flow of**
(a) negative charge (b) positive charge (c) both (a) and (b) (d) none of the above

(23) **The conventional current is due to the flow of**
(a) negative charge carriers (b) neutral charge
(c) positive charge carriers (d) both negative and positive charges carriers.

14.2 Potentional Difference
14.3 E.M.F

(24) **The energy required to move a charge from one point to another in the circuit is called**
(a) e.m.f (b) Potential difference (c) Resistance (d) Volt

(25) **Volt is a unit of**
(a) Potential difference (b) e.m.f
(c) Potential difference and e.m.f. (d) None of these

(26) **The energy supplied in driving one coulomb of charge round a complete circuit in which the cell is connected is called**
(a) e.m.f (b) Potential difference (c) Resistance (d) Volt

(27) **The instrument with which we can detect the presence of current in a circuit is knows as**
(a) Voltmeter (b) Ammeter (c) Galvanometer (d) Ohm meter

(28) **In order to detect the current, galvanometer is connected**
(a) In parallel (b) In series
(c) May be parallel or in series (d) Any where in the circuit

(29) **If the needle of galvanometer shows some deflection, it would indicate the**
(a) Presence of current (b) Absence of current
(c) A large current (d) None of these

(30) **A galvanometer is a very**
(a) Large instrument (b) Small instrument
(c) Insensitive instrument (d) Sensitive instrument

(31) **A resistance which is connected with the galvanometer in order to convert it into ammeter should have**
(a) High resistance (b) Very high resistance
(c) Low resistance (d) Very low resistance

(32) **The resistance of an ammeter should be**
(a) Height (b) Very high (c) Low (d) Very low

(33) **In order to measure the current in a circuit, ammeter should be connected**
(a) Parallel to battery (b) In series in the circuit
(c) May be parallel or in series (d) None of these

(34) **When ammeter is connected in the circuit, the positive terminal of ammeter should be connected with the**
(a) Negative terminal of the battery (b) Positive terminal of the battery
(c) Any terminal of the battery (d) None of these

(35) **The potential difference can be directly measured by the instrument known as**
(a) Ammeter (b) Potentio-meter (c) Voltmeter (d) Ohm meter

(36) **The series resistance which is connected with galvanometer to convert it into voltmeter usually has value in**
(a) Ohms (b) Several hundred ohms
(c) Several thousand ohms (d) Hundred thousand ohms

(37) **Voltmeter is always connected in a circuit in**
(a) Series (b) Parallel
(c) May be in series or parallel (d) None of these

(38) **A good voltmeter is that which draws**
(a) No current (b) Small current (c) Large current (d) Very large current

14.4 Ohm's Law
14.5 V-I Characteristics of Ohmic and Non Ohmic Conductors

(39) **The relation V = IR represents**
(a) Ampere law (b) Coulomb's law
(c) Faraday's law (d) Ohm's law

(40) **Ohm's law is applicable to**
(a) Liquids only (b) Gases only
(c) Liquid conductors only (d) Metallic conductors only

(41) **Ohm is the unit of**
(a) Current (b) Capacitance (c) Electric intensity (d) Resistance

(42) **Ohm is defined as**
(a) Volt/Coulomb or VC^{-1} (b) Volt/Ampere or VA^{-1}
(c) Ampere/Volt or CV^{-1} (d) Ampere/Volt or AV^{-1}

(43) **The resistance of a conductor through which a current of one ampere is flowing when the potential difference across its ends is one volt, is called**
(a) One Volt (b) One coulomb (c) One Ohm (d) One ampere

(44) Thermistor is
(a) A heat sensitive resistor (b) potential divider
(c) constant resistor (d) An ordinary resistor

(45) The graphical representation of Ohm's law is
(a) Hyperbola (b) Ellipse (c) Parabola (d) Straight line

(46) The value of current passing through a conductor is directly proportional to the
(a) Resistance (b) Capacitance (c) Potential difference (d) None of these

(47) The property of a substance which opposes the flow of current through it is called
(a) Conductivity (b) Capacitance (c) Resistance (d) Conduction

(48) If a potential of 220V is applied across a conductor and a current of 2A flows through it. What would be the resistance of the conductor?
(a) 210Ω (b) 440Ω (c) 880Ω (d) 110 ohm

14.6 Specific Resistance (Resistivity) 14.7 and 14.8 Conductors and Insulators

(49) The resistance of a meter cube of the substance is called
(a) conductivity (b) permittivity (c) resistivity (d) susceptibility

(50) At a certain temperature, the resistance of a wire is directly proportional to its
(a) Length (b) Area of cross-section (c) Shape (d) Colour

(51) At a certain temperature, the resistance of a wire is inversely proportional to its
(a) Length (b) Area of cross-section (c) Temperature (d) Colour

(52) If we increase the length of a wire to four times of its original length, what will be its resistance?
(a) The same (b) Doubled (c) Four times (d) Eight times

(53) If we increase the cross-sectional area of the wire to double of its original area, its resistance will become
(a) The same (b) Halved (c) One fourth (d) Doubled

(54) If L is the length and A is the cross-sectional area of a wire, then its resistance is gives by the relation
(a) $R = \frac{1}{\rho}\frac{L}{A}$ (b) $R = \frac{1}{\rho}\frac{A}{L}$ (c) $R = \rho\frac{A}{L}$ (d) $R = \rho\frac{L}{A}$

(55) The SI unit of specific resistance is
(a) $\Omega - m$ (b) $\Omega - m$ (c) $\Omega - m^{-1}$ (d) $\Omega - m^{2}$

(56) If we increase the temperature of a conductor, its resistance will
(a) Increase (b) Decrease (c) Remains the same (d) None of these

(57) The resistance of a conductor does not depend on its
(a) Length (b) Cross sectional area (c) Resistivity (d) Mass

(58) When the temperature of a conductor is raised, its resistance
(a) Always decreases (b) Always increases
(c) Remains the same (d) First increases and then decrease

14.9 Combination of Resistors

(59) The resistances are connected end to end and provide only one path for current in
(a) Parallel circuit (b) Series circuit
(c) Both parallel and series circuit (d) None of these

(60) The potential drop across each of resistors will be same in
(a) Parallel circuit (b) Series circuit
(c) Both parallel and series circuit (d) None of these

(61) **In series circuit, the magnitude of current that flows through each resistor is**
(a) Very small (b) Very large (c) Same (d) Different

(62) **In parallel circuit, the magnitude of current that flows through each resistor will be**
(a) Very small (b) Very large (c) Same (d) Different

(63) **In series combination of resistors, the expression of equivalent voltage is given by**
(a) $V = V_1 + V_2 + V_3$ (b) $V = \frac{1}{V_1} + \frac{1}{V_2} + \frac{1}{V_3}$
(c) $V = V\left[\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}\right]$ (d) $\frac{1}{V} = \frac{1}{V_1} + \frac{1}{V_2} + \frac{1}{V_3}$

(64) **The equivalent resistance for series combination of 3 resistors is given by**
(a) $\frac{1}{R_e} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$ (b) $\frac{1}{R_e} = \frac{V}{R_1} + \frac{V}{R_2} + \frac{V}{R_3}$
(c) $Re = R_1 + R_2 + R_3$ (d) $R_e = VR_1 + VR_2 + VR_3$

(65) **The equivalent resistance for parallel combination of 3 resistors is given by**
(a) $\frac{1}{R_e} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$ (b) $\frac{1}{R_e} = \frac{V}{R_1} + \frac{V}{R_2} + \frac{V}{R_3}$
(c) $Re = R_1 + R_2 + R_3$ (d) $R_e = VR_1 + VR_2 + VR_3$

(66) **The expression for total current through parallel combination is**
(a) $I = I_1 = I_2 = I_3$ (b) $I = I_1 + I_2 + I_3$
(c) $I = I_1 + I_2 + I_3$ (d) $I = 2_1 - 2I_2 - 2I_3$

(67) **If three resistances of 6Ω each are connected in series combination, what will be the equivalent resistance?**
(a) 6Ω (b) 12Ω (c) 18Ω (d) 24Ω

(68) **When resistors are connected in series, the equivalent resistance is equal to**
(a) Sum of the reciprocals of the individual resistance
(b) Product of the reciprocals of the individual resistances
(c) Sum of the individual resistances
(d) Product of the individual resistance

(69) **If the resistors are connected in parallel, then**
(a) The current through each is the same
(b) The total resistance is the sum of individual resistance
(c) The voltage across each is the same
(d) The total resistance is the product of individual resistance

(70) **If the resistance of 2 ohm and 4 ohm are connected in parallel, the equivalent resistance will be**
(a) 11.0 ohms (b) 1.33 ohms (c) 3.0 ohms (d) 5.0 ohms

(71) **Three resistance 5000, 500 and 50 ohms are connected in series across 555 volts mains. The current flowing through them will be**
(a) 1A (b) 100 mA (c) 10 mA (d) 10A

14.10 Electrical Energy and Joule's Law and 14.11 Electric Power

(72) **When Q coulomb of charge flows between the two points having potential difference of V volts then the energy in joules is represented by**
(a) $W = \frac{Q}{V}$ (b) $W = \frac{V}{Q}$ (c) $W = QV$ (d) W = F.S

(73) If a current I ampere flows through a resistance R in time seconds, then the energy supplied will be
(a) $W = IRt$ (b) $W = I^2Rt$ (c) $W = IR^2t$ (d) $W = IRt^2$

(74) The energy supplied $W = I^2Rt$ is the mathematical expression for
(a) Ohm's law (b) Fleming's law (c) Faraday's law (d) Joule's law

(75) The amount of energy supplied by current in unit time is known as
(a) Electrical energy (b) Electrical power (c) Electrical work (d) Potential difference

(76) When current I is flowing through a resistance R the electrical power that generates heat in the resistance is given by
(a) IR (b) I/R (c) I^2R (d) IR^2

(77) The SI unit of electrical power is
(a) Watt (b) Joule (c) Ampere (d) Volt

(78) One watt is equal to
(a) Js (b) Js^{-1} (c) J^2s (d) sJ^{-1}

(79) Heat energy dissipated in a resistor R when connected to a battery of V volts and current I ampere flowing through it for time t is given by
(a) I^2R (b) IRt (c) Vlt (d) I^2Rt

(80) How will you calculate power from current (I) and voltage (v)
(a) power = I/V (b) power = VI (c) power = V^2I (d) power = VI^2

(81) Electrical energy is measured in
(a) watt (b) horse power (c) kilo watt (d) kilowatt hour

(82) Which one of the following bulbs has least resistance?
(a) 100 watt (b) 200 watt (c) 500 watt (d) 1000 watts

(83) Electrical energy is commonly consumed in very large quantity and hence a large unit of energy is required which is know as
(a) Watt-hour (b) Milli-watt hour (c) Killowatt-hour (d) Megawatt - hour

(84) One kilowatt-hour is equal to
(a) 13.6 MJ (b) 13.6 kJ (c) 3.6 kJ (d) 3.6 MJ

(85) We can calculate the amount of electricity bill by the following formula
(a) $\frac{\text{watt} \times \text{time(in hours)}}{1000} \times$ cost of one unit (b) $\frac{\text{watt} \times 1000}{\text{time(in hours)}} \times$ cost of one unit
(c) $\frac{1000 \times \text{time(in hours)}}{\text{Watt}} \times$ cost of one unit (d) $\frac{1000 \times \text{watt} \times \text{time (in hours)}}{\text{cost of one unit}}$

(86) Kilowatt – hour is a unit of
(a) Power (b) Work (c) Energy (d) Current

14.12 Direct Current and Alternating Current
14.13 Hazards of Electricity

(87) The current which always flows in one direction is called
(a) Alternating current (b) Direct current (c) Stationary current (d) Multi-directional

(88) The current which changes its direction again and again is called
(a) Alternating current (b) Direct current
(c) Multi-directional current (d) Uni - directional current

(89) The time interval after which the voltage repeats its value is known as
(a) Frequency (b) Wavelength (c) Time period (d) None of these

(90) The number of cycles completed by current in one second is called its
(a) Time period (b) Frequency (c) Wavelength (d) Amplitude

(91) The frequency of a.c used in our houses is
(a) 30 cycles / second (b) 50 cycles/ second (c) 60 cycles/ second (d) 100cycles/ second

14.14 Safe Use Of Electricity In Homes

(92) All electrical appliances are connected in parallel to each other between the main live and neutral wire to get
(a) same current (b) same current and potential difference
(c) different currents and potential differences (d) same potential differences

(93) Insulated covered wire is called:
(a) Extension (b) Cable (c) Lead (d) None of these

(94) The wire at certain potential is called:
(a) Live wire (b) Neutral wire (c) Earth wire (d) Ground wire

(95) The wire at zero potential is called:
(a) Live wire (b) Neutral wire (c) Earth wire (d) Ground wire

(96) The wire grounded in the earth is called:
(a) Live wire (b) Neutral wire (c) Earth wire (d) Ground wire

(97) A small wire connected in series with the live wire is called:
(a) Neutral wire (b) Earth wire (c) Fuse (d) Circuit breaker

(98) Safety device used in place of fuse is:
(a) Socket (b) Earth wire (c) Plug (d) Circuit breaker

(99) Circuit breaker works on the principle of:
(a) Electric current (b) Joule's law (c) Electromagnetism (d) None of them

(100) An additional wire used in devices having the metallic bodies is:
(a) Live wire (b) Neutral wire (c) Earth wire (d) Ground wire

ANSWER KEY

Q.No	Ans	Q.No	Ans	Q.No	Ans	Q.No	Ans	Q.No	Ans
1.	c	21.	c	41.	d	61.	c	81.	d
2.	c	22.	a	42.	b	62.	d	82.	a
3.	b	23.	c	43.	c	63.	a	83.	c
4.	d	24.	b	44.	a	64.	c	84.	d
5.	b	25.	c	45.	d	65.	a	85.	a
6.	a	26.	a	46.	c	66.	b	86.	c
7.	d	27.	c	47.	c	67.	c	87.	b
8.	a	28.	b	48.	d	68.	c	88.	a
9.	b	29.	a	49.	c	69.	c	89.	c
10.	c	30.	d	50.	a	70.	b	90.	b
11.	b	31.	d	51.	b	71.	b	91.	b
12.	d	32.	c	52.	c	72.	c	92.	d
13.	c	33.	b	53.	b	73.	b	93.	b
14.	c	34.	b	54.	d	74.	d	94.	a
15.	b	35.	c	55.	b	75.	b	95.	b
16.	a	36.	c	56.	a	76.	c	96.	c
17.	b	37.	b	57.	d	77.	a	97.	c
18.	b	38.	b	58.	b	78.	b	98.	d
19.	b	39.	d	59.	b	79.	d	99.	c
20.	a	40.	d	60.	a	80.	b	100.	c

SHORT QUESTIONS

14.1 Electric Current

Q.1. Define electric current.

Ans: The rate of flow of electric charge through any cross- sectional area is called, electric current. If the charge Q is passing through an area A in time t second, then the current flowing through it will be I, whereas

Mathematically

$$\text{Current} = \frac{\text{charge}}{\text{time}}$$

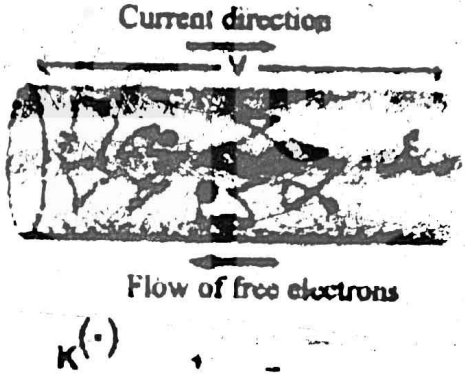
$$I = \frac{Q}{t}$$

Unit

In system International, the unit of current is known as ampere.

Q.2. What is meant by conventional current?

Ans: "A current produced due to flow of negative charges is equivalent to a current due to flow of an equal amount of positive charge in opposite direction. This equivalent current of positive charge is known as conventional current".



Q.3. Which type of charge is responsible for the flow of current in metallic conductors?

Ans: In metals or metallic conductors, the current is due to the flow of free electrons i.e. negative charges. For example, in a copper wire there are large number of free electrons which are in random motion. When we apply potential difference across the wire, these free electrons move through the wire.

Q.4. In electrolyte which charge are responsible for the flow of current?

Ans: The molecules of electrolytes are dissolved among positive and negative ions in a solution. Thus current in electrolytes is due to the flow of both positive and negative charges **as shown in fig.**

Q.5. How energy is obtained due to flow of charges?

Ans: When a positive charge moves from a point of higher potential to the point of lower potential, it gains the energy from the electric field. During flow of electric current, positive charges flow continuously from a high potential to a low potential point. Thus the electric current becomes a continuous source of energy.

14.2 Potentional Difference
14.3 E.M.F

Q.6. How a galvanometer is converted into voltmeter?

Ans: The galvanometer is converted into voltmeter by connecting suitable resistance in series with it. The value of the resistance depends upon the range of the voltmeter. Usually its value is several thousand ohms. Thus the resistance of a voltmeter is very high.

Q.7. How a galvanometer is converted into ammeter?

Ans: Galvanometer can be converted into an ammeter by connecting a small resistance parallel to it. This small resistance is known as "shunt". Shunt provides an alternative path for the current to flow. The major part of the current passes through the shunt and small fraction of it flows through the galvanometer.

Q.8. Why resistance of the ammeter is kept low?

Ans: If the resistance of the ammeter is kept high, then high amount of current flows through the galvanometer. When high amount of current will flow through the galvanometer then galvanometer can be burnt. That is why resistance of the ammeter is kept low

Q.9. Why resistance of the voltmeter is kept high?

Ans: If the resistance of the voltmeter is comparatively low, it will draw more current from the circuit. Due to this the potential difference across the resistance for the measurement, of which the voltmeter was connected, would drop.

Q.10. On what factor reliability of voltmeter depend?

Ans: Higher the resistance of the voltmeter, more reliable would be its readings. Therefore a good voltmeter should have such a high resistance so that no or very little current could pass through it.

Q.11. Differentiate between electromotive force and potential difference.

Ans:

Difference between electromotive force and potential difference.	
Electromotive force	**Potential difference**
The electromotive force of a battery or cell is the total energy supplied in driving one coulomb charge round a complete circuit in which cell is connected. The complete circuit includes the cell and external circuit connected to the terminals.	The potential difference determines the energy between any two points of the circuit which is required in moving a charge from one point to another.

14.4 Ohm's Law
14.5 V-I Characteristics of Ohmic and Non Ohmic Conductor

Q.12. State and explain Ohm's law. Write down its limitations. (16.4)

Ans: "The value of current I passing through a conductor is directly proportional to the potential difference V applied across its ends, provided the temperature and the physical state of the conductor does not change."

Mathematical form

$V \propto I$ Or $V = IR$ ..... (1)

Limitations of Ohm's Law

Ohm's law is applicable only in case of metallic conductors when their temperature and physical state do not change.

Q.13. Define resistance and its unit.

Ans: "The property of a substance which opposes the flow of current through it is called its resistance."

Mathematically:

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

Where R is resistance, V is potential difference and I is current. S.I unit of resistance is Ohm. Which is define as

Ohm

"If a current of one ampere passes through it when a potential difference of one volt is applied across its ends then resistance would be one Ohm. Ohm is usually represented by the Greek letter Ω

Mathematically

$$1\Omega = \frac{IV}{IA}$$

14.6 Specific Resistance (Resistivity) 14.7 and 14.8 Conductors and Insulators

Q.14. What are the factors upon which the resistance of a conductor depends?

Ans: Resistance of the conductor depends upon the following factors:

- Length of the conductor (L)
- Area of cross-section of the conductor (A)
- Nature of the conductor
- Temperature

Q.15. Why does the resistance of a conductor increase with the rise of its temperature?

Ans: When the temperature of the conductor rises, average speed of the random motion of the free electrons increases which enhances the rate of collision of electrons and atoms. This causes an increase in the resistance of the conductor.

Q.16. Why do we always use metal wires for conduction of electricity?

Ans: Because, they are good conductors of electricity and offer less resistance to the flow of current. Metals like silver and copper have excess of free electrons which are not held strongly with any particular atom of metals. These free electrons move randomly in all direction inside metals. When we apply external electric field these electrons can easily move in a specific direction. This movement of free electrons in particular direction under the influence of external field causes flow of current in metal wires.

Q.17. What do you mean by Insulators?

Ans: The substances through which almost no current flow are called Insulators

Examples: The examples of insulators are as followings glass, wood, plastic, fur, silk etc.

14.9 Combination of Resistors
14.10 Electrical Energy and Joule's Law and
14.11 Electric Power

Q.18. State Joule's Law.

Ans: The amount of heat generated in a resistance due to flow of charges is equal to the product of square of current I, resistance R and the time duration t.

Mathematically:

$$W = I^2Rt$$

Where W is work done (Energy), I is current, R is resistance and t is time duration.

Q.19. Define electric power.

Ans: The amount of energy supplied by current in unit time is known as electric power.

Mathematically:

$$\text{Power} = \frac{\text{Work}}{\text{Time}} \quad , \quad P = \frac{QV}{t} = IV = I^2R$$

Q.20. Define kilowatt hour?

Ans: Kilowatt – Hour

The amount of energy delivered by a power of one kilowatt in one hour is called kilowatt – hour.

Mathematically:

One kilowatt – hour 1kwh = 1000 w x 1 hour

= 1000 w x (3600s)

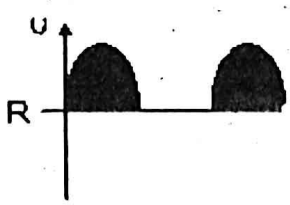
= 36×10^5 J = 3.6 MJ

14.12 Direct Current and Alternating Current
14.13 Hazards of Electricity

Q.21. Differentiate between A.C and D.C.

Ans:

Difference between A.C. and D.C.

Alternating current (A.C.)	Direct current (D.C.)
• The current which changes its direction again and again is called alternating current. • A.C current can transfer electrical energy over the long distances and can provide more power. • The frequency of alternating current is 50Hz. • A.C current is obtained from A.C generators and mains. • **Wave form of A.C**  **AC Current** **Example** Current used in our houses.	• A current which always flows only in one direction is called the direct current. • Voltage of D.C cannot travel very far until it begins to lose energy. • The frequency of the D.C current is zero. • D.C current is obtained from batteries and cells. • **Waveform of D.C**  **DC Current** **Example** Current from dry cells.

Q.22. What are live and neutral wires?

Ans: Electricity is distributed to various houses in a city from a power station by means of two wires.

Neutral wire

One wire is earthed at the power station, so it is at zero potential. This wire is called neutral wire. This wire provide the return path of current. It is a black or blue in colour.

Live wire

The other wire on power station is at some certain potential called the live wire. The potential difference between both wire is 220. It is red or brown in colour.

Q.23. How electricity is dangerous for us?

Ans: Our body is a good conductor of electricity through which current can easily pass. Therefore if a person holds live wire, then because of the presence of voltage in it, current will start flowing to ground through the human body which may prove fatal for the person.

14.14 Safe Use of Electricity In Homes

Q.24. What is cable? And how it should be used?

Ans: "An insulated covered wire is known as cable".

Cable should be used keeping the following things in mind:

- **Layer of insulation** in the cable is perfect and is not damaged.
- Sometimes a **heavy current** flow through the wire and it gets so hot that its insulation is burnt out and the wire becomes naked and it becomes dangerous.
- **Constant friction** also removes the insulation from the wire whereas too much moisture also damages the insulation. In such a situation it is advisable to use a cable with two layers of insulation.

Q.25. Define fuse and write down its principle.

Ans: "A small wire connected in series with the live wire is known as fuse wire or fuse".

Principle

A specified amount of current can safely pass through it. When the current following through it exceeds this limit, it gets so hot that it melts.

Q.26. What do you know about Fuse rating?

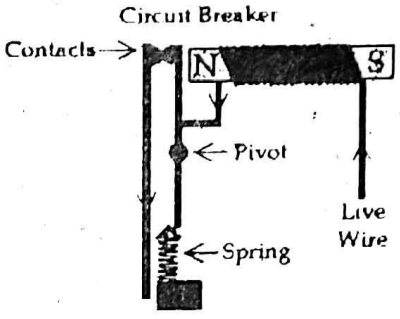
Ans: We can determine the required fuse rating for a circuit. Suppose we want to insert a fuse for an air-conditioner or heater of power 3000W. If voltage supply is of 240V, then according to relation $P = V \times I$, we get $I = 12.5A$. The available fuses in the market are usually of rating 5A, 10A, 13A, 30A etc. Hence, suitable fuse for this circuit would be of 13A.

Q.27. What is Circuit Breaker? Also write down its principle.

Ans: It is a safety device which is used in place of fuse. Due to any fault when the current exceeds the safety limit, then the button of the circuit breaker moves upward. Due to which the circuit breaks and the flow of the current is stopped in it.

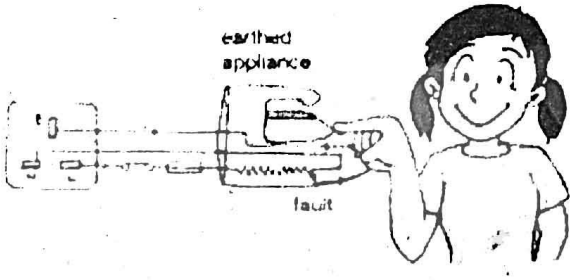
Principle

The current flowing through the electric circuit also flows through the coil of the circuit breaker due to which the coil becomes electromagnet. When the current is within its limits, the contact points of the circuit are connected to each other and the circuit is completed. As soon as the current exceeds the limit, the magnetic force of the electromagnet is so increased that it attracts the iron strip towards it. Hence the contact points are separated and the circuit breaks.



Q.28. What is the working principle of Earth wire?

Ans: Whenever the metal casing of the appliance, due to faulty insulation, gets connected with the live wire, the circuit shorts and a large current would immediately flow to ground through the earth wire and causes the fuse wire to melt or the circuit breaker breaks the circuit. Therefore, the person who is using the appliance is saved.

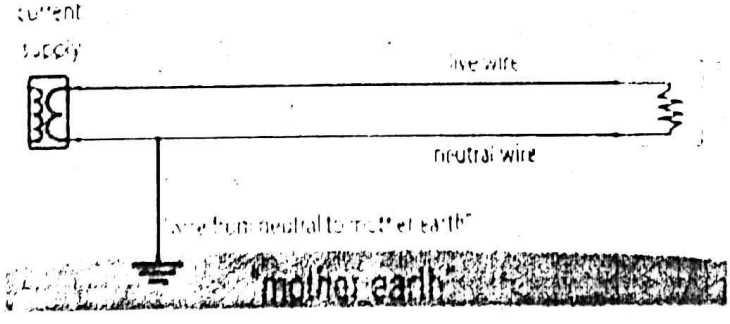


Q.29. On what principle circuit breaker work?

Ans: The current flowing through the electric circuit also flows through the coil of the circuit breaker due to which the coil becomes electromagnet. When the current is within its limits, the contact points of the circuit are connected to each other and the circuit is completed. As soon as the current exceeds the limit, the magnetic force of the electromagnetic is so increased that it attracts the iron strip towards it. Hence the contact points are separated and the circuit breaks.

Q.30. How earth wire is useful to us?

Ans: Whenever the metal casing of the appliance, due to faulty insulation, gets connected with the live wire, the circuit shorts and a large current would immediately flow to ground through the earth wire and causes the fuse wire to melt or the circuit breaker breaks the circuit. Therefore, the person who is using the appliance is saved.



14.1 Electric Current

Q.1 Define and explain the term electric current (14.1).

Ans: Definition:

"The rate of flow of electric charges through any cross-sectional area is called current."

Mathematically:

If charges 'Q' is passing through any area in time't' the current 'I' flowing through it will be given as"

$$\text{current} = \frac{\text{charge}}{\text{time}}$$

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

Unit: SI unit of current is Ampere (A)

Ampere:

One ampere is the amount of electric current due to the flow of electric charge at the rate of one coulomb per second.

$$1A = \frac{1\text{COLOUMB}}{1\text{second}} = \frac{1c}{1s}$$

Flow of current through a conductor

Consider a conductor in form of a copper wire. It has a large number of free electrons which are in random motion just like the molecules of a gas confined in a container. Their movement does not obey any symmetry but they move in all directions.

Motion of free electrons in absence of electric field

In absence of an electric field, rate at which the free electrons cross any section of the wire from right to left is equal to the rate at which they cross from left to right with the result that the net rate is zero.

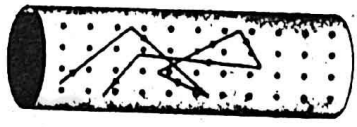


Fig. 16.3

So in-spite of the fact that electrons are in motion, no current flows through any section of the conductor.

Motion of free electrons in presence of electric field

If one end of the copper wire is connected with positive terminal of a battery and other with its negative terminal, an electric field E is established at each point of wire. Now the free electrons, because of their negative charge, experience a force in a direction opposite to the direction of electric field E.

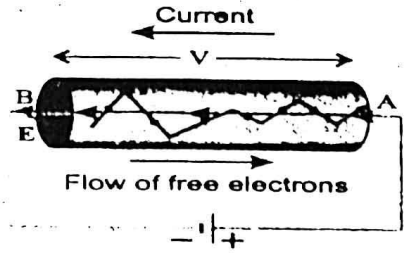


Fig. 16.4

Because of this force a net directed flow of free electrons takes place from the negative terminal of the battery towards its positive terminal and an electric current begins to flow through the wire from the positive terminal towards the negative terminal of the battery.

Direction of flow of current

The current flow due to negative charges has been changed with conventional current. This current flows in the wire from positive to negative terminal of the battery i.e., current flows from a point of higher potential to a point of lower potential

Current in solutions (electrolyte)

In case of electrolyte its molecules in aqueous solution dissociate among positive and negative ions. So current in electrolyte is produced due the flow of both positive and negative charges.

Q.2 **Explain battery as source of energy (14.1)**

Battery is one of the sources of current. The electrochemical reaction inside a battery separates positive and negative electric charges as shown in fig.

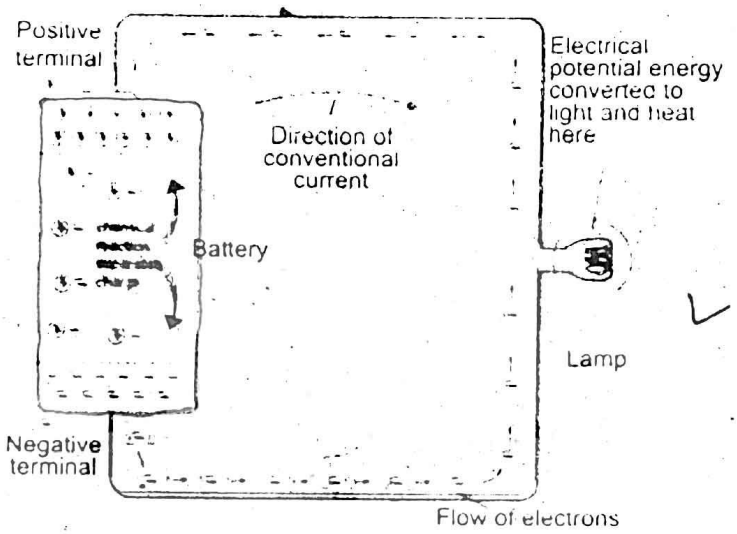


Fig.14.1: Schematic diagram of battery as a current source

This separation of charges set up potential difference between the terminals of the battery. When we connect a conducting wire across the terminals of the battery, the charges can move from one terminal to the other due to the potential difference.

Potential energy per unit charge:

The chemical energy of the battery changes to electrical potential energy. The electrical potential energy decreases as the charges move around the circuit. This electric potential energy can be converted to another useful forms of energy (heat, light, sound etc.) it is only the energy which changes form but the number of charge carriers and the charge on each carrier always remains the same (i.e. charge are not used up.) instead of electrical potential energy we use the term electrical potential which is potential energy per unit charge.

Q.3 **Define and explain the term conventional current (14.1).**

Ans: Definition

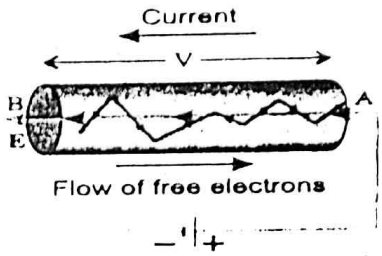
"Current flowing from positive to negative terminal of battery due to flow of positive charges is called conventional current."

Convential mean

Before the idea of free electrons which constitute in metals, it was thought that current in conductors flowed due to motion of positive charges. Therefore, this convention is still in used.

Explanation

When the ends of a copper wire are at different temperatures, heat energy flows from one end of higher temperature to the end of lower temperature. The flow stops when both ends reach the same temperature. Water in pipe also flows in a pipe from high level to low level. Similarly when a conductor is connected to a battery, it pushes positive charges to flow current from high potential to low potential as shown in fig.



The flow of current continues as long as there is a potential difference. Conventional current produces the same effect as the current flowing from negative terminal to the positive terminal due to flow of negative charges.

Q.4 **How we can detect and measure the electric current (14.1)?**

Ans: We use different electrical instruments which can detect and measure the current in the circuit.

1. **Galvanometer:**

"Galvanometer is a device which is used to detect the presence of electric current in any circuit."

ii. **Ammeter:**

"Ammeter is a device which is used to measure the current in any circuit."

Importance of Galvanometer

Galvanometer is very sensitive instruments and can detect small current. A current of few milli amperes is sufficient in it. Ideal galvanometer should have very small resistance to pass the maximum current in the circuit.

Polarity of galvanometer

While making the connections polarity of the terminals of the galvanometer should be taken into consideration. Generally the terminal of the galvanometer with red colour shows the positive polarity while that of with black colour shows negative polarity.

How Ammeter is formed?

After suitable modification galvanometer can converted into an ammeter. A suitable but small resistance is connected in parallel to the galvanometer, this circuit is called ammeter. A large current of the range such as 1A or 10 A can be measured by means of ammeter, like galvanometer ammeter is also connected in series, so that the current flowing in the circuit also passes through the ammeter.

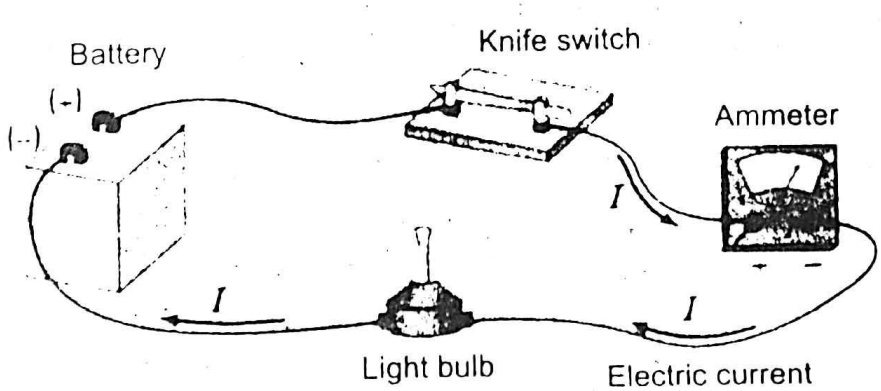


Fig. 14.5: Schematic diagram showing the measurement of current

14.2 and 14.3 Potential Difference and e.m.f

Q.5: **Define and explain the potential difference (14.2).**

Ans: **Definition:**

"Potential difference across the two ends of a conductor causes the dissipation of electrical energy into other forms of energy as charges flow through the circuit.

Explanation:

When one end A of conductor is connected to the positive terminal and its other end B is connected to the negative terminal of the battery then the potential of A becomes higher than the potential of as shown in figure.

This cause a potential difference between the two ends of the conductor. The flow of current continues as long as there is a potential difference. The agent which provides the steady flow of current in the copper wire is the battery. As the current flows form higher potential to the lower potential through the conductor, the electrical energy (due to current) is converted into to other form i.e. heat and light etc.

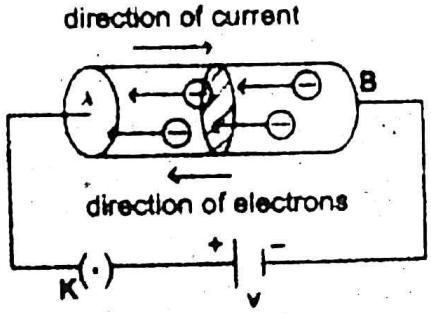


Fig.14.6

When current flows through the conductor, it experiences a resistance in the conductor. The energy supplied by the battery is utilized in overcoming this resistance and is dissipated as heat and other form of energy. The dissipation of this energy is accounted for by the potential difference across the two ends of the conductor (light bulb)

SI unit of potential difference is volt.

A potential difference of I volt across a bulb means that each coulomb of charge or 1 ampere of current that passes through the bulb consumers 1 joule of energy. When a bulb is lit, the energy is taken from the current and is transformed into light and heat energy.

Q.6 What is mean by electromotive force? Write its equation and explain its unit.(14.3)

Ans: Definition of e.m.f

"It is the energy converted form non-electrical form when one coulombs of positive charge passes through the battery".

OR

"it is the energy supplied by a battery to a unit charge when it flows through the closed circuit".

Equation:

$$emf = \frac{energy}{charge}$$

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

Where 'W' is energy converted from non-electrical forms to electrical form and 'Q' is a positive charge.

Unit of e.m.f

SI units of energy and charge are Joule and coulomb, then the unit of em.f will be JC^{-1} i.e.

$$emf = \frac{energy}{charge}$$

$$= JC^{-1}$$

$$e.mf = volt$$

Hence if the e.m.f of the battery is 2V, the total energy supplied by the battery is 2 Joules when one coulombs of charge flows through the closed circuit.

Explanation

Sources of e.m.f

Batteries, thermocouples and generators are the best examples of the sources of e.m.f When a conductor is connected to battery current flows through it due to potential difference. A source of electromotive (e.m.f) converts non-electrical energy (chemical, thermal, mechanical into electrical energy.

How do charges move a circuit?

Battery supplies energy to the charges for continuous flow of current. The positive charges leave the positive terminal of the battery, pass through the conductor and reach the negative terminal of the battery. As this positive charge enters the battery at its lower potential point (negative terminal), the battery must supply energy, say W to the positive charge derive it to appoint of higher potential (positive terminal).

Q.7 **How we measured the potential difference and e.m.f across a circuit?(14.3),**

Ans: **The Measurement of potential Difference**

The potential difference across a circuit component (e.g., light bulb) can be measured by a voltmeter (Fig.) connected directly across the terminal of the component. The positive terminal of the cell is connected to the positive terminal of the voltmeter and the nega ve terminal of the cell is connected to the negative terminal of the voltmeter. An ideal voltmeter should have very large value of resistance so that no current passes through it, voltmeter is always connected in parallel with the device across which the potential difference is to be measured (Fig)

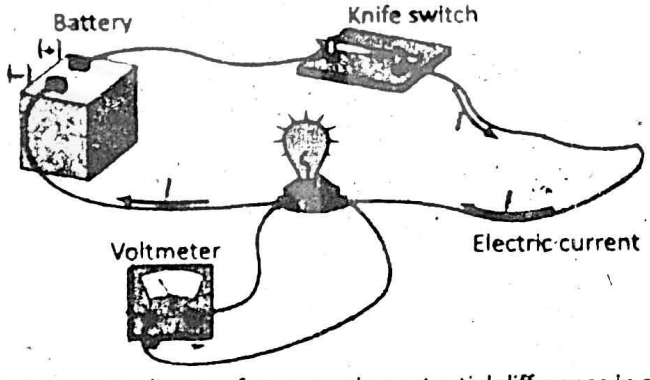


Fig. 14.8: Schematic diagram for measuring potential difference in a circuit.

The measurement of e.m.f

In general e.m.f refers to the potential difference across the terminals of the battery when it is not driving current in the external circuit. So in order to measure e.m.f of the battery we connect voltmeter directly with the terminals of the battery as shown in

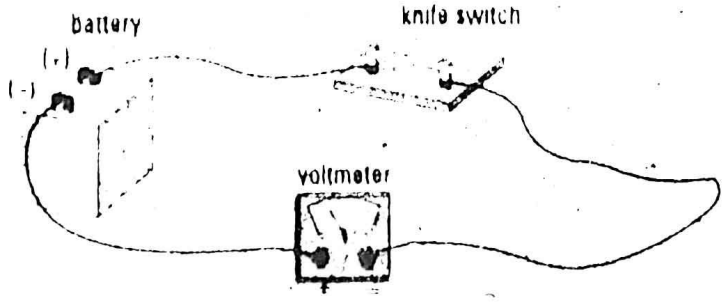


Fig. 14.9: Schematic diagram for measuring e.m.f. of the battery

14.4 Ohms's Law



Q.8 States and explain Ohm's law. What are its limitation?

Ans: Ohm's law:

The amount of current I passing through a conductor is directly proportional to the potential difference V applied across its ends, provided the temperature and the physical state of the conductor does not change.

Explanation:

If 'V' is the potential difference across the two ends of any conductor, then current I will flow through it. The value of the current 'I' changes with the changes in potential difference 'V', hence by the definition of Ohm's law.

$$V \propto I$$
$$V = (\text{Constant}) \quad (I)$$
$$V = (R)I$$
$$V = IR \ldots\ldots\ldots\ldots (1)$$

Where 'R' is the constant of proportionality, and is the resistance of the conductor. Its SI units is Ohm.

Resistance:

"The property of a substance which offers opposition to the flow of current through it is called its resistance".

Unit:

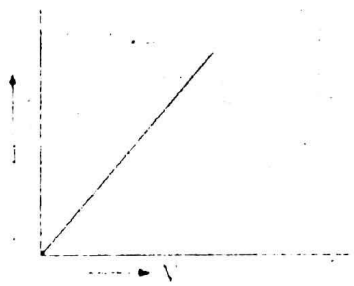
SI unit of the resistance 'R' is Ohm. It is denoted by the symbol, called Omega (Ω).

Definition of Ohm:

"When a potential difference of one volt is applied across the ends of a conductor and 1 ampere of current passes thorough it, then its resistance will be one ohm"

Graphically representation:

If a graph is plotted between the current 'I' and the potential difference 'V' a straight line will be obtained.



Limitations of Ohm's Law:

Ohm's law is applicable when temperature of conductor is kept constant. It has been observed that only good conductors obey ohm's law as long as the electric current through them is not very large and the physical state of the conductor also remains the same.

14.5 Characteristics of Ohmic and Non Ohmic conductors

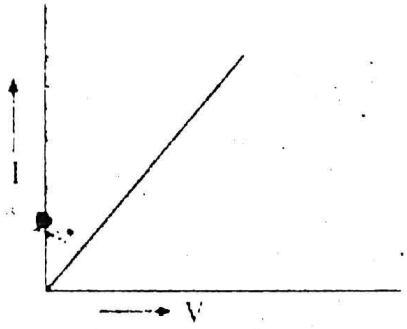
Q.9 Explain the V-I characteristics of Ohmic and non Ohmic conductor.(14.5)

Ans: Materials that obey Ohm's law, and hence have a constant resistance over a wide range of voltages, are said to be Ohmic."

Ohmic Conductor:

Ohmic conductors have a linear current-voltage relationship over a wide range of applied voltages as shown in figure:

The straight line shows a constant ratio between voltage and current, So Ohm's law is obeyed. For example most metals show Ohmic behavior.



(i) Ohmic

None-Ohmic Conductor

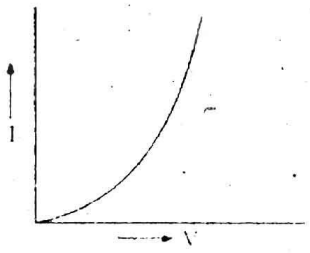
Non-Ohmic materials have a non-linear current-voltage relationship.

Example:

(i) Filament lamp
(ii) Thermister
(iii) Filament lamp

(i) **Filament lamp:**

The filament lamp shows the non-Ohmic materials properties. The resistance of filament rises (current decreases) as it gets hotter, which is shown by the gradient getting steeper as shown in fig.

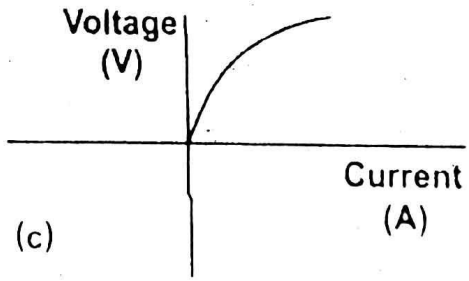


(ii) Non-ohmic

(ii) **Thermister:**

A thermister (a heat sensitive resistor) behaves in the opposite way as that of filament lamp. Its resistance decreases (current increases) as it gets hotter as shown in fig.

This is because on heating, more free electrons become available for conduction of current.



Q.10: Define resistance and its units.

Ans: Resistance:

"The property of a substance which offers opposition to the flow of current through it is called its resistance".

Reason:

Opposition to the flow of current is due to the collisions of the moving electrons with atoms of the substance.

Unit:

SI unit of the resistance 'R' is Ohm. It is denoted by the symbol, called Omega (Ω).

Definition of Ohm:

Since, V = IR

If we put V = 1 volt and I = 1 Ampere the value of 'R' will be 1 ohm, Thus, "When a potential difference of one volt is applied across the ends of a conductor and 1 ampere of current passes thorough it, then its resistance will be one ohm"

14.6 Specific Resistance (Resistively)

Q.11 Define and explain the term specific resistance. Discuss different factors which affect the resistance of conductors.(14.6)

Ans: Definition:

"The resistance of one meter cube of a substance is called its specific resistance".

Explanation:

A short pipe offers less resistance to water flow than a long pipe. A pipe with larger cross-sectional area offers less resistance than the pipe having smaller cross-sectional area.

Same is the case for resistance of wire that carry current .the resistance of wire depends both on the cross-sectional area and length of the wire, current flow also depends upon the nature of the material of the wire.

Factors:

At specific temperature resistance depends upon the following factors.

(a) Length of conductor:

Longer wires have more resistance than short wires.

(b) Cross-sectional area of conductor

Thick wires have less resistance than thin wires.

(c) Nature of the conductor:

Copper wire has less resistance than steel wire of the same size.

Note: Electrical resistance also depends on temperature.

MATHEMATICALLY EXPLANATION OF SPECIFIC RESISTANCE

At a certain temperature and for a particular substance;

(1) **Length and Resistance;**

The resistance 'R' of wire is directly proportional to the length of the wire i.e.

$$R \propto L \rightarrow (i)$$

It means if we double the length of wire its resistance will also be double and , if its length is halved its resistance would become one half.

(2) **Cross-sectional area and resistance**

The resistance 'R' of the wire is inversely proportional to the area of cross-section 'A' of the wire .i. c.

$$R \propto \frac{1}{A} \longrightarrow (ii)$$

It means that a thick wire would have smaller resistance than a thin wire.
By combining these above relations.

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

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

$$R = \rho\frac{L}{A} \longrightarrow (iii)$$

Where 'ρ' is the constant of proportionality, known as specific resistance.

Nature of conductor (specific resistance)

Where ρ is the constant of proportionality known as specific resistance. Its value depends upon the nature of conductor i.e., copper, iron, tin and silver would each have a different values of ρ.

Unit of specific resistance

In above equation, if L = 1 m and A = $1m^2$ then R = p i.e., the resistance of one meter cube of a substance is equal to its specific resistance. According to above equation the unit of p is ohm-meter (Ωm)

14.7 and 14.8 Conductor and Insulators

Q.12: What is the difference between the conductors and insulators?(14.7 and 14.8)

Ans: **Conductors:**

Why do we always use metal wires for conduction of electricity? Because, they are good conductors of electricity and offer less resistance to the flow of current. But how can they conduct electricity with much ease? Metals like silver and copper have excess of free electrons which are not held strongly with any particular atom of metals. These free electrons move randomly in all direction inside metals. When we apply external electric field these electrons can easily move in a specific direction. This movement of free electrons in particular direction under the influence of external field causes flow of current in metal wires. The resistance of conductors increases with increase in temperature. This is due to increase in the number of collisions of electrons with the themselves and the atoms of metals.

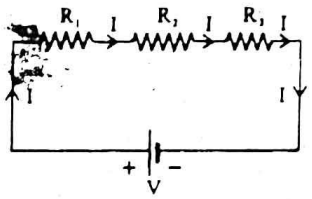
Insulators

All materials contain electrons. The electrons in insulators, like rubber, however, are not free to move they are tightly bound inside atoms. Hence, current cannot flow through an insulator because there are no free electrons for the flow of current. Insulators have very large value of resistance. Insulators can be easily charged by friction and the induced charge remains static on their surface. Other examples of insulators are glass, wood, plastic, fur, silk etc.

14.9 Combination of Resistors

Q.13: How are resistance are connected in series? Describe the characteristics features of this combination. What is meant by equivalent resistance of a series combination? Find its value.(14.9)

Ans: In this method resistance are connected end to end and the circuit thus formed provides only one path for the flow of current.1



Characteristics of series combination

(i) In this arrangement, the magnitude of current that flows through each individual resistor is same.

(ii) In series combination, the sum of voltages across each of the resistor is equal to the voltage of the battery connected across the combination. If the voltage of the battery is V and V_1, V_2, V_3 are the voltages across the resistors R_1, R_2, R_3 respectively, then

$$V = V_1 + V_2 + V_3$$

If the current passing through the resistors R1, R2, and R3 is I, then

$$V = IR_1 + IR_2 + IR_3$$

$$V = I(R_1 + R_2 + R_3) \quad \ldots\ldots\ldots \quad (1)$$

Equivalent resistance of series combination

The equivalent resistance R_e of a series combination is that resistance which is substituted in place of the combination, the same current would flow through the circuit. Figure shows the equivalent resistance Re. Note that the battery is sending the same current, which it was sending when the combination was connected in the circuit. By Ohm's law,

$$V = IR_e$$

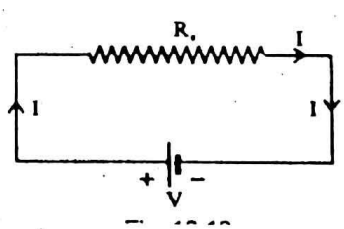
By substituting the value of V in equation (1), we have

$$IR_e = I(R_1 + R_2 + R_3)$$

$$R_e = R_1 + R_2 + R_3$$

Thus the equivalent resistance of a series combination is equal to the sum of the individual resistances of the combination.

If resistances R_1, R_2, R_3, ..., R_n are connected in series then their equivalent resistance can be determined by the following equation.



$$R_e = R_1 + R_2 + R_3 + \ldots\ldots + R_n$$

Q.14: How are resistance are connected in parallel? Describe the characteristics features of this combination. What is meant by equivalent resistance of a parallel combination? Find its value. (14.9)

Ans: In this combination, resistances are connected in such a way that one end of all the resistors is connected to one point, say 'A' and the other ends to another point 'B' as shown in the figure.

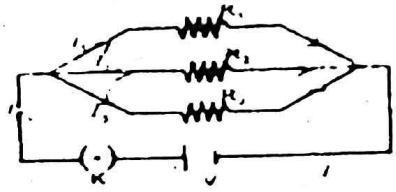


Fig 14.12 Three resistors in parallel combination

In the circuit formed, several paths are available for the flow of current. The total current is divided in these paths. The parallel combination has the following characteristics.

Features of Parallel combination

(i) In this combination, the potential drop across all the resistances is the same. The potential drop across each of the resistance in the figure will be V.

(ii) The sum of the current flowing through the various resistances of this combination is equal to the total of the circuit.

$$I = I_1 + I_2 + I_3 \quad \ldots\ldots\ldots \quad (1)$$

As the potential drop across each resistance is V. So by Ohm's law

$$I_1 = \frac{V}{R_1} \qquad I_2 = \frac{V}{R_2} \qquad I_3 = \frac{V}{R_3}$$

By substituting the values of I_1, I_2, I_3 in equation (1), we have

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

Or
$$I = V\left(\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}\right) \quad \ldots\ldots\ldots \quad (2)$$

(iii) The equivalent resistance R_e of the parallel combination is that resistance which when substituted in place of the parallel combination does not alter the total current of the circuit.

By Ohm's law $I = \frac{V}{R_e}$

By putting the value of I in equation (2), we have

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

Or
$$\frac{1}{R_e} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

If resistances R_1, R_2, R_3, ..., R_n are connected in parallel then their equivalent resistance can be determined by the following equation.

$$\frac{1}{R_e} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \ldots\ldots + \frac{1}{R_n}$$

Advantages of Parallel

Parallel circuits have two big advantages over series circuits.

(i) Each device in the circuit receives the full battery voltages.

(ii) Each device in the circuit may be turned off independently without stopping the current flowing to other devices in the circuit. This principle is used in our wiring.

14.10 Electrical energy and Joule's Law

Q. 15: State and explain joule's law. Derive its formula.(14.10)

Ans: Joule's law:



Statement:

"The amount of heat energy generated in a resistance due to flow of charges in equal to the product of square of current 'I' resistance 'R' and the time during 't'."

Explanation:

When water falls on turbine form higher gravitational. Potential to lower gravitational potential. Then electrical energy is produced by the running of generator.

Similarly when charge moves form a higher electrical potential to a lower potential it delivers electric current.

Hence the electric current, during when charges continuously move form a higher potential to a lower potential, becomes a continuous source of electrical energy.

Mathematics formula:

Consider two point with a potential difference 'V' volts. If one coulomb of charge passes between these points, the amount of energy delivers by the charge would be V joule, when 'Q' coulomb of charge flows between these two points, then we get QV joule of energy. It is represented by W.

$$\text{i.e. } W = QV \rightarrow (i)$$

When charge 'Q' flow in time 't' then by definition of current, we have.

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

$$\Rightarrow Q = It \qquad \rightarrow (ii)$$

Put eq (ii) in eq (i)

$$W = It\,V \rightarrow (iii)$$

This electrical energy can be converted into heat and other forms in the circuit.

By Ohms law, we have

$$V = IR \rightarrow (iv)$$

Put eq.(iv) in eq (iii) we get

$$W = It\,(IR)$$

So energy supplied by 'Q' charge in given as:

$$W = I^2 Rt$$

This equation is called joules law.

Importance:

The heat energy produced can be utilized for different useful purposes. E.g.

(i) Bulb converts this energy into light and heat.

(ii) Heater and Iron convert this heat energy into heat.

(iii) Electric fans convert into mechanical energy.

Note: When current pass through conductor (heater) we get heat

14.11 Electric Power:

Q. 16: What is electric power? How it is calculate and write its unit.(14.11)

Ans: Electric power:

"The amount of energy supplied by current in unit time is known as electric power

How power can be determined?

If the work done by the electric current in time 't' is 'W' then 'P' is determined by the formula.

$$\text{Electric power} = \frac{\text{electrical energy}}{\text{time}}$$

$$P = \frac{W}{t} \longrightarrow (i)$$

Where 'w' is the electrical energy given as:

$$W = QV \rightarrow (ii)$$

$$P = \frac{QV}{t} \rightarrow (iii)$$

By definition of current

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

Hence eq. (iii) becomes

$$P = IV \rightarrow (iv)$$

By Ohm's law

$$V = IR \rightarrow (iv)$$

Hence equation (iv) can be written as:

Electrical power = P = I (IR)

Electrical power = $P = I^2R$

When current I is passing through resistor R, the electric power that generates heat in the resistance is given by I^2R.

Unit:

The unit of electric power is watt which is equal to one joule per second. It is represent by the symbol W.

Examples:

Electric bulbs commonly used in houses consume 25w, 40w, 60w, 75w, and 1000 w of electric power.

Q.17 What is kilowatt hour? How the cost of electricity in a house can be a calculated?

Ans: "The amount of energy delivered by a power of one kilowatt in one hour is called kilowatt hour."

Explanation:

Electric energy is commonly consumed in very large quantity for the measurement of which joule is a very small unit hence a very large unit of electric energy is needed which is called kilowatt hour.

One kilowatt hour = Kwh

$= 1000W \times (3600s)$

$= 36 \times 10^5$ Ws

$= 3.6 \times 10^6$Ws

$\therefore 10^6$ = Mega = M, Ws = J

Hence,

One kilowatt hour = 3.6MJ

Formula:

$$\text{The amount of energy in kwh} = \frac{\text{Power(watt)} \times \text{time of use in hours}}{1000}$$

Or

$$\text{No. of units consumed} = \frac{\text{Power(watt)} \times \text{time of use in hours}}{1000}$$

Calculation for cost of Electricity in House:

The electric meter installed in our houses measures the consumption of electric energy in units of kilowatt hour according to which we pay our electricity bills. If the cost of one kilowatt-hour i.e., one unit is known then cost of electricity is calculated as:

Formula:

Cost of electricity = number of units consumed × cost of one unit

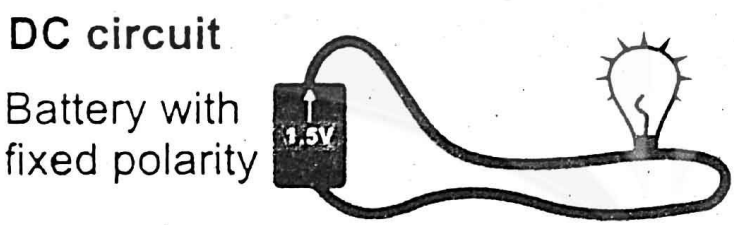
$$\text{Cost of electricity} = \frac{\text{Power(watt)} \times \text{time of use in hours}}{1000} \times \text{cost of one unit}$$

14.12 Direct current and alternating current

Q.18: What is difference between D.C. and A.C.? OR
Compare direct current (D.C) and alternating current (A.C)(14.12)

Ans: "The current which does not change its direction of flow is known as direct current or d.c."

The current derived from a cell or a battery is direct current (D.C.) since it is unidirectional. The positive and negative terminals of d.c. sources have fixed polarity, therefore, level of d.c. remains constant with time as shown in figure.



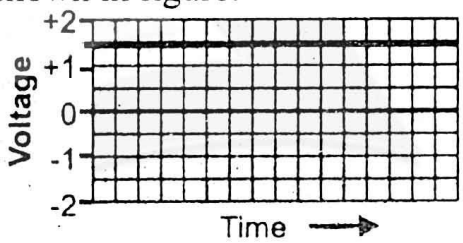
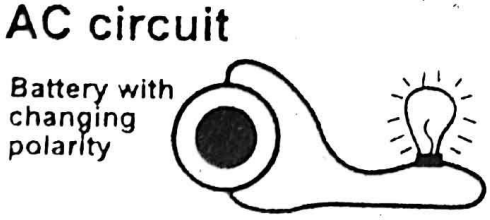
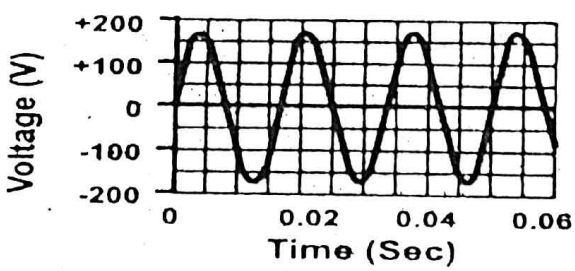


Fig. 14.13: Variation of D.C Current with time.

Alternating Current (A.C)

"The current which changes its direction of flow after regular intervals of time is known as alternating current or A.C." The current produce by A.C generators changes its polarity again and again as shown in fig:





Characteristics of A.C

Time period: The interval after which the A.C. voltage or current repeat its value is known as time period.

Cycle:

The set of all the value of current during one period is known as one cycle"

Frequency: The number of cycles completed by alternating current in one second is called its frequency."

The change in the values of voltage and current corresponds to the frequency of the source. In Pakistan, alternating current oscillates 50 time every second. Thus, its frequency is 50Hz.

Importance of A.C:

Alternating current has advantages that make it more practical for use in transferring electrical energy. The current supplied to our homes by power companions is alternating current.

Q.19. How electricity is distributed in our house? How electrical appliances are connected in houses?(14.12)

Ans: Supply to Houses:

The electric power enters our house through three wires. One is called earth wire or ground wire (E). This caries no electricity. The earthy wire is connected to a large metal plate buried deep in the ground near the house the other wire is maintained as zero potential by connecting it to the earth at the power station itself and is called neutral wire (N). This wire provides the return path for the current. The third wire is at a high potential and is called live wire (L).

Potential difference between live wire and neutral wire:

The electric power enters our houses through wires, the potential difference between the live wire and neutral wire is 220V.

Dangers

Our body is a good conductor of electricity through which current can easily pass. Therefore, if a person holds live wire current will start flowing to the ground while passing through his body which may prove fatal for the person.

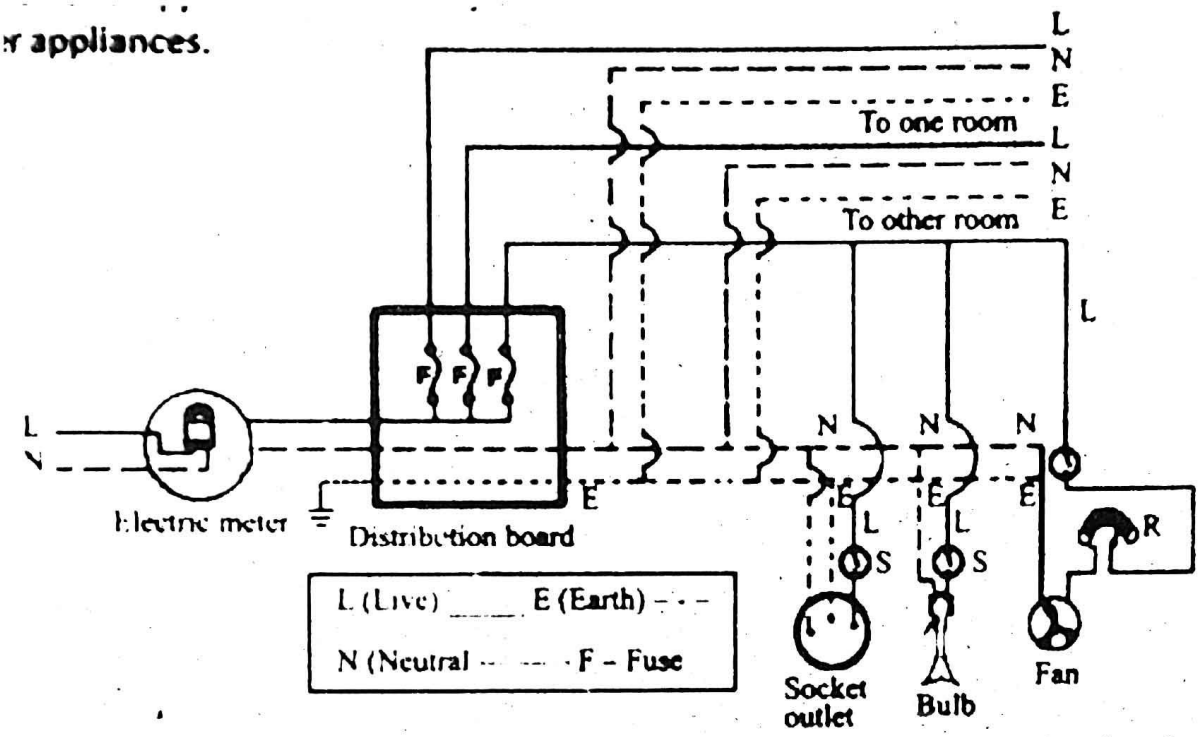
How electric appliances are connected?

All electrical appliances are connected across the neutral and live wires. The same potential difference is therefore applied to all of them and hence these are connected in parallel to the power source.

Q.20 Explain the circuit of house wiring.

Ans: The wires coming from power sub-station are connected to electricity meter installed in house. The output power from the electric meter is taken to the distribution board and then to the domestic electric circuit.

r appliances.



The main box contains fuses of rating about 30A.A separate connection is taken from the live wire for each appliance. Terminal of the appliance is connected to the live wire through a separate fuse and a switch. If the fuse of the one appliance burns out, it does not affect the other appliances.

How all appliances are connected?

In house wiring all appliances are connected in parallel with each other. This means they get the full mains voltage and one can turn on any appliance without having to turn on another.

14.13 Hazards of electricity:

Q. 21: Discuss some faults in electrical circuits that may cause electricity hazards.(14.13)

Ans: Electricity has become part and parcel of our lives, care should be taken to save ourselves form its hazardous effects.

Major dangers:

Major dangers of electricity are:

(i) Electric shock.

(ii) Fire.

Some major faults in electrical Circuit:

These are the major faults in electrical circuits that may cause electrical hazards.

1. **Insulation Damage:**

How insulation damage:

(i) **Excess of current:** Electrical current exceeds the rated current carrying capacity of the conductor it can produce excess current that can damage insulation due to overheating of cables.

(ii) **Friction:** Constant friction may also remove the insulation from the wire.

(iii) **Moisture:** Too much moisture also damages the insulation because moisture decrease resistance and increase the rate of current.

How Circuit become short?

(i) A short circuit occurs when circuit with a very low resistance is formed. The low resistance causes the current to be very large.

(ii) When appliances are connected in parallel, each additional appliances placed in circuit reduces the equivalent resistance (Re) in the circuit increase the current through the wires. This additional current might produce enough thermal energy to melt the wiring's insulation, cause a short circuit, or even start a fire.

(iii) Short circuit can also occur when the live wire and the neutral wire come in direct contact.

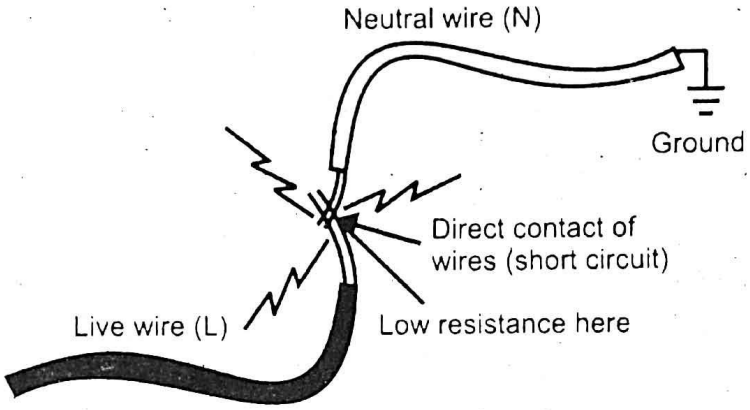


Fig. 14.16: Short circuit

Precautions:

Cable: All electrical wires are well insulated with plastic cover for the purpose of safety. Plastic is a good insulator. Such an insulation covered wire is called cable

i. In order to avoid dangerous situation it is advisable to use a cable with two layers of insulation.

ii. Don't use naked current carrying wires.

iii. Do not fly kites near electricity naked lines. It may cause some fatal accident.

2. **Damp Conditions:**

We environment is called damp conditions.

Dry human skin has a resistance of 1000,000 ohms or more. But under damp conditions resistance of human skin is reduced drastically to few hundred ohms. Therefore never operate any electrical appliance with wet hands. The switches, plugs, sockets and wires must be dry.

14.14 Safe Use of Electricity in Homes

Q. 22: Briefly describe the importance of safety devices.(14.14)

Ans: "The electrical devices which prevent the damage of electrical circuits appliances and property are called safety devices.

Examples:

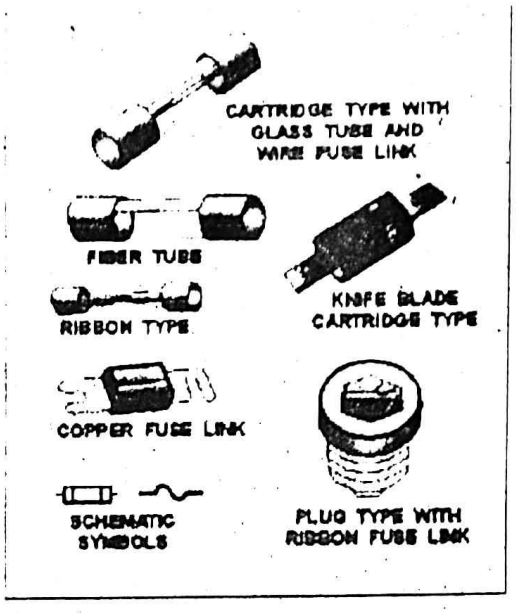
(i) Fuse
(ii) Circuit Breaker
(iii) Earth wire

Importance:

In order to protect persons, devices and property form the hazards of electricity. There is a need of extensive safety measures in household electricity. Safety devices prevent circuit form overloading that can occur when too many appliances are turned on at the same time or when a short circuit occurs in one appliance.

Q.23: Write a note on fuse:

Ans: Definitions: "A fuse is a safety device that is connected in series with the live wire in the circuit to protect the equipments when excess current flows."



Construction: Fuse is made of a short and thin piece of metal wire that melts when large current passes through it.

Working: If a large, unsafe current passes through the circuit, the fuse melts and breaks the circuits before the wires becomes very hot and cause fire.

Fuse rating: Fuse are normally rated as 5A, 10A, 13A and 30 A etc.

We can determine the fuse rating of circuit, let use determine the fuse rating of air conditions of power 3000W.

$$P = 3000W.$$
$$V = 240 \text{ Volt}$$
$$I = ?$$
$$P = VI$$
$$\Rightarrow \quad I = \frac{P}{V}$$
$$I = \frac{300}{240} = 12.5A$$

Hence suitable fuse for this circuit would be 13A.

Safety Measures:

Following safety measures should be taken while using fuses in house hold electrical circuits.

(i) fuses to be used should have slightly more rating than the current which the electrical appliance in will draw under conditions. For example, for a lightening choose a 5A fuse as the current drawn by each lamp is very small (about 0.4A) for a 100 W lamp. In such circuit 10 lamps of 100 W can be safely used because the total current drawn is only 9A which can be calculated using the formula P = VI

(ii) Fuses should be connect to the live wire so that the appliance will not become live after the fuse has blown.

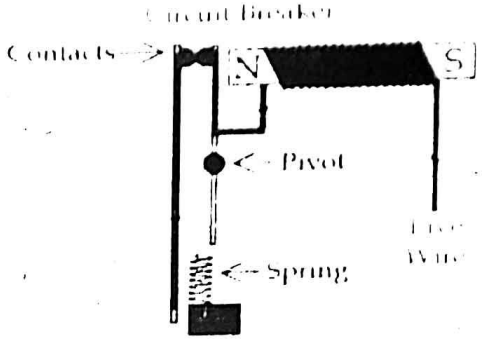
(iii) Switch off the main before changing any fuse.

Q. 24: What is the principle of circuit breaker?(14.14)

Ans: Circuit Breaker:

The circuit breaker acts as a safety device in the same way as a fuse. It disconnects the supply automatically if current exceeds the normal value.

Working principle: When the normal current passes through the live wire the electromagnet is not strong enough to separate the contacts. If something goes wrong with the appliance and large current flows through the live wire, the electromagnet will attract the iron strip to separate the contracts and break the circuit. The spring then keeps the contacts apart as shown in figure.



After the fault is repaired, the contacts can then be pushed back together by pressing a bottom on the outside of the circuit breaker box.

Q. 25: Explain the importance of Earth wire.(14.14)

Ans: Earth Wire:

Sometimes, even the fuse cannot capture the high currents coming from the live wire into the household appliance. Earthing further protects the user form electric shock by connecting the metal casing of the appliance to earth (a wired connection to the bare ground) many electrical appliances have metal cases, including cookers, washing machines and refrigerators, the earth wire provides a safe route for the current to flow through, if the live wire touches the cashing as shown in fig below.

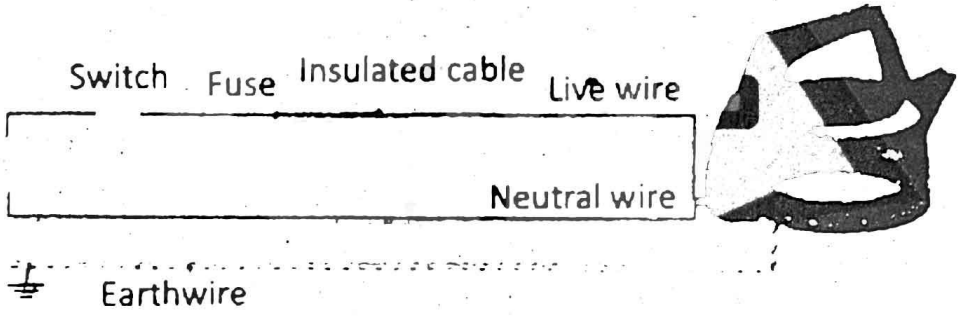


Fig. 14.20

We will get an electric shock if the live wire inside an appliance comes loose and touches the metal casing, However, the earth terminal is connected to the metal cashing, so the current goes though the earth wire instead of passing through our body and causing an electric shock, A strong current passes through the earth wire because it has a very low resistance. This breaks the fuse and disconnects the appliance.

Working principle of Earth wire

Whenever the metal casing of the appliance, due to faulty insulation, gets connected with the live wire, the circuit shorts and a large current would immediately flow to ground through the earth wire and causes the fuse wire to melt or the circuit breaker breaks the circuit. Therefore, the person who is using the appliance is saved.

UNSOLVED NUMERICAL PROBLEMS

Q.14.1 A current of 3mA is flowing through wire for 1 minute. What is the charge flowing through the wire?

Solution

Given Data

$$\text{Current} = I = 3\text{mA}$$
$$I = 3 \times 10^{-3}\ \text{A} \quad (\because \text{milli} = \text{m} = 10^{-3})$$
$$\text{Time} = t = 1\text{min}$$
$$T = 1 \times 60 = 60\ \text{sec.}$$

Required:

$$\text{Charge} = Q = ?$$

Formula

$$I = \frac{Q}{T}$$
$$\Rightarrow \quad Q = I \times t$$
$$Q = 3 \times 10^{-3} \times 60$$
$$Q = 180 \times 10^{-3}\ \text{C Ans}$$

Q. 14.2 At 100,000 Ω how much current flows through your body if you touch the terminals of a 12-V battery? If your skin is wet, so that your resistance is only 1000 Ω, how much current would your receive form the same battery?

Solution:

Given Data

$$R_1 = 100,000$$
$$V = 12\ \text{volts}$$
$$R_2 = 1000\ \Omega$$

Required

(a) $I_1 = ?$

(b) $I_2 = ?$

(a) **Formula:**

$$V = IR$$

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

$$I_1 = \frac{V}{R_1}$$

$$I_1 = \frac{12}{100{,}000}$$

$$I_1 = \frac{12}{10^5}$$

$$I_1 = 12 \times 10^{-5} A$$

$$I_1 = 1.2 \times 10^{-4} A \text{ Ans}$$

(b) **Formula:**

$$V = IR$$

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

$$I_2 = \frac{V}{R_2}$$

$$I_2 = \frac{12}{1000}$$

$$I_2 = 12 \times 10^{-3} A$$

$$I_2 = 1.2 \times 10^{-2} A \text{ Ans}$$

Q.14.3 The resistance of a conductor wire is 10 MΩ. If a potential difference of 100 volt is applied across its ends. Then find the value of current passing through it in mA.

Solution:

Given Data

Resistance = R = 10 MΩ = $10 \times 10^6 \Omega$ ($\because M = 10^6$)

Potential difference = V = 1000 volt

Required:

Current = I = ?

Formula

V= IR

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

$$I = \frac{100}{10 \times 10^6}$$

$$I = 10 \times 10^{-6}$$

$$I = 10^{-5} A$$

$$I = 10^{-2} \times 10^{-3} A$$

$$I = \frac{1}{10^2} mA$$

$$I = \frac{1}{100} mA$$

$$I = 0.01 \text{ mA}$$

Q.14.4 By applying potential difference of 10 V across a conductor a current of 1.5A passes through it. How much energy would be obtained from the current in 2 minutes?

Solution:

Given Data

$V = 10$ volt

$I = 1.5$ Amp

Time $= t = 2\text{min} = 2 \times 60 = 120$ sec.

Required:

Energy $= W = ?$

Formula:

$W = I^2Rt$

$W = I(IR)t$

$W = I(V)t$

$W = (1.5)(10)(120)$

$W = 1800J$ **Ans.**

Q.14.5 Two resistances of 2kΩ 8kΩ are joined in series, if a 10V battery is connected across the ends of this combination, find following quantities.

(a) **The equivalent resistance of the series combination.**

(b) **Current passing through each of the resistances.**

(c) **The potential difference across each resistance.**

Solution:

Given Data

Value of first resistance	=	R1	=	$2K\Omega = 2\times10^3\Omega$
Value of second resistance	=	R2	=	$8K\Omega = 8\times10^3\Omega$
Potential of battery	=	V	=	10V

Required:

(a) Equivalent resistance in series	=	Re	=	?
(b)Current through each resistance	=	I	=	?
(c)Potential difference across first resistance	=	V1	=	?
Potential difference across second resistance	=	V2	=	?

Formula:

(a) Equivalent resistance $= R_e = R_1 + R_2$

$Re = 2K\Omega + 8K\Omega$

$= 10K\Omega$

Hence equivalent resistance is 10KΩ

(b) As the circuits is in series so same value of current will pass through each resistance.

$I = I_1 = I_2$

$= V = IRe$

By putting value

$$I = \frac{10}{10\times10^{3}}$$

$$I = 1\times10^{3}$$

$$I = 1mA$$

(c) Potential difference across first resistance = $V_1 = IR_1 = 1\times10^{-3}\times2\times10^{3}$

$$= 2V$$

Potential difference across second resistance $= V_2 = IR_2$

$$= 1\times10^{-3}\times8\times10^{3}$$

$$= 8V$$

Hence current through each resistance is 1mA and potential difference across first resistance is 2V and potential difference across second resistance is 8V.

Q.14.6 Two resistance of 6kΩ and 12kΩ are connected in parallel. A 6V battery is connected across its ends, find the values of the following quantities:

(a) Equivalent resistance of the parallel combination.

(b) Current passing through each of the resistances.

(c) Potential difference across each of the resistance.

Solution

Given Data

$R_1 = 6K\Omega = 6\times10^{3}\Omega$

$R_2 = 12K\Omega = 12\times10^{3}\Omega$

$V = 6V$

(a) Equalvalent resistance $R_e = ?$

(b) Potential differnce across $R_1 = V_1 = ?$

Potential differce across $R_2 = V_2 = ?$

(c) Current through resistance $R_1 = I_1 = ?$

Current through resistancer $R_2 = I_2 = ?$

(a) **Formula:**

$$\frac{1}{R_e} = \frac{1}{R_1}+\frac{1}{R_2}$$

$$\frac{1}{R_e} = \frac{1}{6\times10^{3}}+\frac{1}{12\times10^{3}}$$

$$= \frac{2+1}{12\times10^{3}}$$

$$= \frac{3}{12\times10^{3}}$$

$$\frac{1}{R_e} = \frac{1}{4\times10^{3}}$$

$$R_e = 4K\Omega$$

Hence equivalent resistance is **4KΩ**

(b) As the circuit is parallel so potential difference across each resistance is equal to potential of battery,

$$V = V_1 = V_2 = 6V$$

(c) Quantity of current through first resistance $= I_1 = \frac{V_1}{R_1}$

$$= \frac{6}{6\times10^3}$$

$$= 1 \times 10^{-3}$$

$$I_1 = 1mA$$

Quantity of current though second resistance $I_2 = \frac{V_2}{R_2}$

$$= \frac{6}{12\times10^3}$$

$$= \frac{1}{2\times10^3}$$

$$= 0.5 \times 1^{-3}$$

$$I_2 = 0.5mA$$

Hence quantity of current is 1mA and 0.5 mA

Q.14.7 An electric bulb is marked with 220V, 100W. Find the resistance of the filament of the bulb. If the bulb is used 5 hours daily, find the energy in kilowatt-hour consumed by the bulb in one month (30 days).

Solution

Given Data

Voltage of bulb	=	V	=	220V
Power of bulb	=	P	=	100W
Daily use of bulb	=	t	=	5h
No. of days for bulb	=	30days		

Required:

Resistance of bulb filament	=	R	=	?
Energy consumed by bulb	E	=	?	

Formula

$$P = I^2R$$

But according to Ohm's law

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

So

$$P = \left(\frac{V}{R}\right)^2 \times R$$

$$P = \frac{V_2}{R_2} \times R$$

$$P = \frac{V_2}{R}$$

$$R = \frac{V_2}{P}$$

By putting values

$$R = \frac{(220)^2}{100}$$

$$R = \frac{48400}{100}$$

$$\mathbf{R = 484\Omega}$$

Time in 30 days $= 30 \times 5 = 150$ hours

Energy in kilowatt hour $= \frac{\text{Power (Watt)} \times \text{time (hour)}}{1000}$

$$= \frac{150 \times 100}{1000}$$

$$= 15\text{kWh}$$

$$= 15\text{kWh}$$

Q.14.8 An incandescent light bulb with an operating resistance of 95 Ω is labeled "150 W." Is this bulb designed for use in a 120-V circuit or a 220-V circuit? Explain with calculations. (it has been designed for 120 V as is evident form the power formula i.e.(P =VI). Ans.

Solutions:

Given Data

$R = 95\Omega$

Power = P = 150 W

Required:

For which voltage bulb is designed = ? (120V or 220V)

Formula:

$$P = I^2R$$

$$150 = I^2(95)$$

$$\Rightarrow \quad I^2 = \frac{150}{95}$$

$$I^2 = 1.5784$$

$$\sqrt{I^2} = \sqrt{1.578}$$

$$I = 1.2565$$

$$V = IR$$

$$V = (1.2565)(95)$$

$$V = 119.37\text{volt}$$

$$V = 120\text{volt}$$

This bulb is designed for 120V

Q.14.9 A house is installed with

(a) **10 bulbs of 60 W each of which are used 5 hours daily.**

(b) **4 fans of 75W each of which run 10 hours daily.**

(c) **One T.V. of 100 W which is used 2 hours daily.**

(d) **one electric iron of 1000 W which us used hours daily.**

If the cost of one unit of electricity is Rs. 4. Find the monthly expenditure of electricity (one month = 30 days)

Solution

Given Data

Power of 10 bulbs	=	60×10	=	600 W
Power of 4 fans	=	75×4	=	300 W
Power of 1 iron	=	1000×1	=	1000W
Power of 1 T.V	=	100×1	=	100 W
Price of per unit	=	Rs. 4		

Required:

Monthly cost of electricity of house = ?

Formula:

$$\text{Energy consumed by bulb} = \frac{\text{Power (Watt)} \times \text{time (hour)}}{1000}$$

$$= \frac{600 \times 5 \times 30}{1000} = \frac{90000}{1000}$$

$$= 90 \text{ unit}$$

$$\text{Energy consumed by fans} = \frac{\text{Power (Watt)} \times \text{time (hour)}}{1000}$$

$$= \frac{300 \times 10 \times 30}{1000} = \frac{60 \times 1000}{1000}$$

$$= 60 \text{ Units}$$

$$\text{Energy consumed by T.V} = \frac{100 \times 5 \times 30}{1000} = \frac{100 \times 150}{1000}$$

$$= 15 \text{ units}$$

Total consumed energy in units = 90 + 90 + 60 + 15

= 255 Units

Price of electricity = $255 \times 4 = 1020$ Rs.

Hence total price of electricity is 1020 rupees.

Q. 14.10 A 100 W lamp bulb and a 4 kW water heater are connected to a 250 V supply. Calculate

(a) The current which flows in each appliance and

(b) The resistance of each appliance when in use

Solution:

Given Data

Power = $P_1 = 100W$ (lamp)

Power = $P_2 = 4kW$ (heater)

$P_2 = 4 \times 10^2 W$

$V = 250$ Volts

Required:

(a) $I_1 = ?$

$I_2 = ?$

(b) $R_1 = ?$

$R_2 = ?$

Formula:

Current in Lamp; (I_1)

$P = VI_1$

$P_1 = VI_1$

$\Rightarrow \quad I_1 = \frac{P_1}{V_1}$

$I_1 = \frac{100}{250}$

$I_1 = 0.4A$ Ans.

(a) Current in heater; (I_2)

$P = VI$

$P_2 = VI_2$

$\Rightarrow I_2 = \frac{P_2}{V}$

$I_2 = \frac{4 \times 10^3}{250}$

$I_2 = 0.016 \times 10^3 A$

$I_2 = 16A$ Ans.

(b) Resistance of Lamp; (R_1)

$V = IR$

$V = I_1 R_1$

$250 = (0.4)R_1$

$\frac{250}{0.4} = R_1$

$625\Omega = R_1$

$R1 = 625\Omega$ Ans.

(c) Resistance of heater; (R_2)

$$V = IR$$
$$V = I_2R_2$$
$$250 = 16(R_2)$$
$$\frac{250}{16} = R_2$$
$$15.625\Omega = R_2 \text{ Ans.}$$

Q.14.11 A resistor of resistance 5.6 Ω is connected across a battery of 3.0 V by means of wire of negligible resistance. Current of 0.5 A passes through the resistor. Calculate the

(a) power dissipated in the resistor

(b) total power produced by the battery

(c) Give the reason of difference between these two quantities.

Solution: Given that,

Resistance R = 5.6Ω

Voltage V = 3V

Current I = 0.5A

Required:

(a) Power dissipated P = ?

(b) power produced by the battery P = ?

(c) Why these two quantities differ = ?

Calculations:

Using the formula

$P = VI$

We know that

$V = IR$

$P = I^2R$

By putting the values

$P = (0.5A)^2 (5.6\Omega)$

$= 0.25A \times 5.6\Omega$

P = 1.4W Ans.

(b) Using the formula

$P = VI$

By putting the values

$P = 3V \times 0.3A$

P = 1.5 W Ans.

(c) Because some power is lost by the internal resistance of the battery