UNIT 14

CURRENT ELECTRICITY

14.1 ELECTRIC CURRENT

LONG QUESTIONS

Q.1 Define and explain the term electric current. ***(K.B+U.B)*** **(LHR 2016)(Review Question 14.1)**

Ans:

ELECTRIC CURRENT

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:

If a charge of one coulomb passes through a cross-sectional area in one second, then current is one ampere.

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

Smaller units of current are milli ampere (mA), micro ampere (μA), which are defined as:

$$1\text{mA} = 10^{-3}\text{A}$$

$$1\mu\text{A} = 10^{-6}\text{A}$$

Flow of Current:

Most of the electric charge around nuclei is bound in neutral atoms. It is not easy to overcome the electrostatic force of attraction between the nuclei and electrons in an atom. However, in metals some electrons are not tightly bound to nuclei and are free to move around randomly. They have weak force between them and the nucleus. Similarly, in solutions some positive and negative charges can freely move around randomly. When such free charges are exposed to an external electric field, they move in a specific direction, and thus constitute current.

Q.2 Explain battery as source of energy. ***(K.B+U.B+A.B)***

Ans:

BATTERY AS A SOURCE OF ENERGY

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

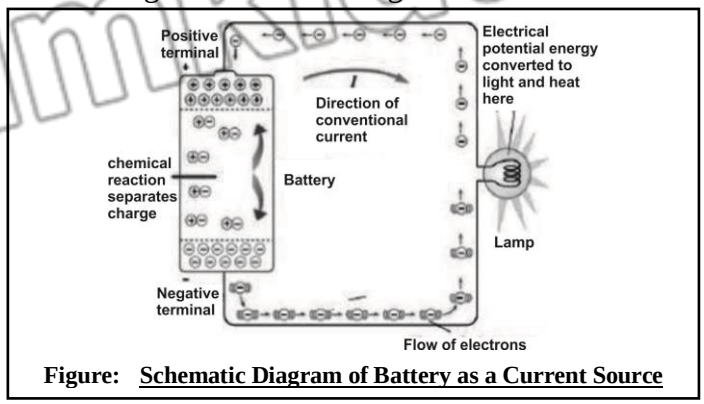


Figure: Schematic Diagram of Battery as a Current Source

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. ***(K.B)*** **(GRW 2013)**

Ans:

CONVENTIONAL CURRENT

Definition:

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

Conventional 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 heated 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 a pipe also flows from higher level to lower level. Similarly when a conductor is connected to a battery, it pushes positive charges to flow current from high potential to low potential.

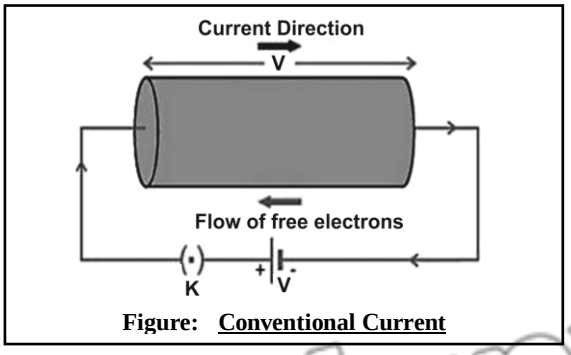


Figure: Conventional Current

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? ***(K.B+A.B)***

Ans:

DETECTION AND MEASUREMENT OF CURRENT

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

Galvanometer:

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

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 in a circuit. A current of few milli amperes is sufficient to cause full scale deflection 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.

Conversion of Galvanometer into Ammeter:

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.

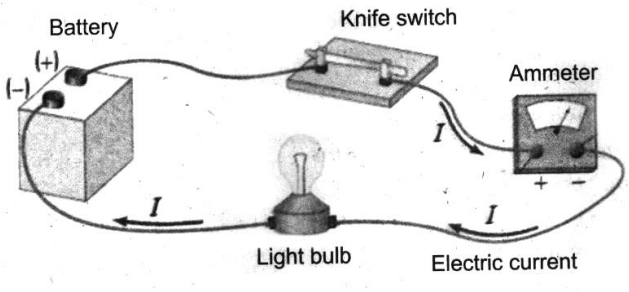


Figure: Schematic Diagram Showing the Measurement of Current

14.1 SHORT QUESTIONS

Q.1 Define electric current. ***(K.B)*** **(GRW 2014, 2015, LHR 2011, 2016)**

Ans: ***Given on Page # 204***

Q.2 What is meant by conventional current? ***(K.B)***

Ans: ***Given on Page # 205***

Q.3 Which type of charge is responsible for the flow of current in metallic conductors? ***(K.B)***

Ans:

CURRENT IN METALLIC CONDUCTOR

In metals or metallic conductors, the current is reduced only due to the flow of free electrons i.e. negative charges.

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.

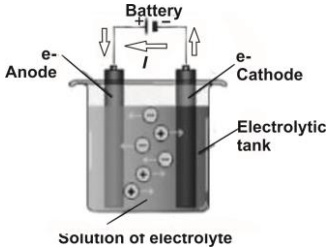
Q.4 In electrolyte which charge are responsible for the flow of current? ***(K.B)***

(For your information Pg. # 91)

Ans:

CURRENT IN ELECTROLYTE

In electrolysis, current is produced due to flow of both positive and negative charges in the electrolyte, positive ions are attracted to the cathode and negative ions are attracted to the anode. This movement of ions within the electrolyte constitutes an electric current within the internal circuit.



Q.5 How energy is obtained due to flow of charges? ***(K.B)***

Ans:

ENERGY DUE TO FLOW OF CHARGES

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.

Q.6 How long does it take a current of 10 mA to deliver 30 C of charge? ***(U.B+A.B)***

(Quick Quiz Page No. 92)

Ans:

NUMERICAL

Solution:

Given:

Current=I=10mA

$I=10\times10^{-3}A$

Charge=Q=30C

To Find:

Time=t=?

Formula Used:

I=Q/t

Or

t=Q/I

Calculations:

Putting the values into the formula from given data

$t = 30C/10\times10^{-3}A$

$t = 3\times10^{3}s$

t = 3000s

Result:

Hence, time To Find is 3000s.

Q.7 Define unit of current. ***(K.B+U.B)*** **(GRW 2014, LHR 2017)**

Ans: ***Given on Page # 204***

Q.8 Why there is no current in conductor in the absence of external source despite it has free electrons? ***(K.B)*** **(Connection Pg. # 92)**

Ans:

NO CURRENT IN THE ABSENCE OF EXTERNAL SOURCE

In the absence of any external source no current passes through the conductor due to random motion of electrons.

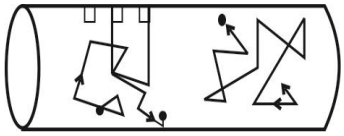


Figure: No Current in the Absence of External Source

Q.9 How a battery does raises electrical charge back up to higher voltage (energy)? *(U.B)*
(For you information Pg. # 92)

Ans: **BATTERY CHARGING**

A battery raises electric charge back up to higher voltage (energy) just like a pump which pushes water back up to high energy so it can flow and do work again.

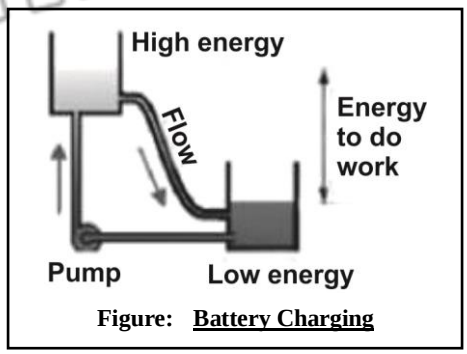


Figure: Battery Charging

Q.10 Define electric current with the help of diagram. *(K.B)* **(For you information Pg. # 91)**

Ans: **ELECTRIC CURRENT**

The current is the rate of flow of charges.

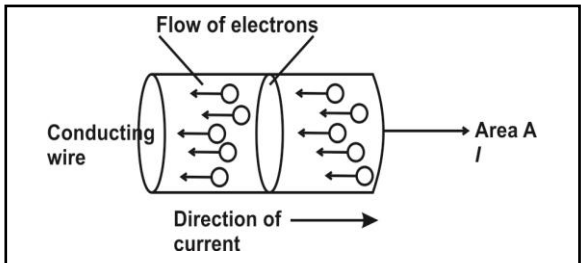


Figure: Electric Current

Q.11 Describe the flow of charge in a circuit. *(K.B)* **(Physics Insight Pg. # 93)**

Ans: **FLOW OF CHARGE**

The flow of charge in a circuit is like the flow of water in a pipe except that a return wire is needed in order to have a complete conducting path.

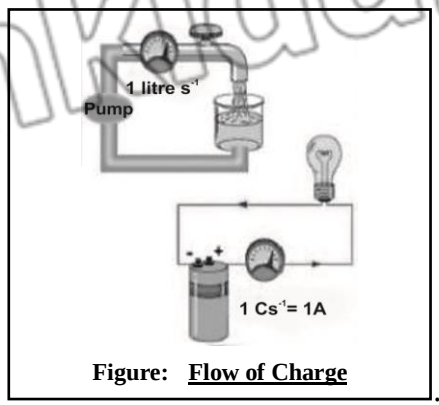


Figure: Flow of Charge

14.1 MULTIPLE CHOICE QUESTIONS

1. In metals, current is produced only due to the flow of: ***(K.B)***
(A) Protons (B) Electrons
(C) Free electrons (D) Neutrons

2. In electrolyte, current is produced due to the flow of: ***(K.B)***
(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: ***(K.B)***
(A) Electrostatics (B) Electric current
(C) e.m.f (D) Voltage

4. The SI unit of electric current is: ***(K.B)***
(A) Volt (B) Farad
(C) Capacitance (D) Ampere

5. The equivalent current of positive charges which flows through a conductor is known as: ***(K.B)***
(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: ***(K.B)***
(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: ***(K.B)***
(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: ***(K.B)***
(A) Higher potential to a point of lower potential
(B) Lower potential to a point of higher potential
(C) Lowe 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: ***(K.B)***
(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? ***(K.B)***
(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: ***(K.B)***
(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: ***(K.B)***
(A) Protons (B) Neutrons
(C) Electrons (D) Free electrons

13. In liquids and gases, the current is due to the motion of: ***(K.B)***
(A) Negative charges (B) Positive charges
(C) Both negative and positive charges (D) Neutral particles

14. Free electrons are: ***(K.B)***
(A) Tightly bound (B) Fixed
(C) Loosely bound (D) Tightly fixed

15. The direction of conventional current flowing in a circuit is: ***(K.B)***
(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: ***(K.B)***
(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: ***(U.B+A.B)***
(A) I = Qt (B) I = Q/t
(C) I = t/Q (D) I = Q2/t

18. One coulomb per second is equal to: ***(K.B)***
(A) One volt (B) One Ampere
(C) One watt (D) One Ohm

19. Which of the following represents an electric current? ***(K.B)***
(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: ***(U.B+A.B)***
(A) 3600 C (B) 7200 C
(C) 1C (D) 2C

21. Batteries convert: ***(K.B+U.B)***
(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: ***(K.B)***
(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: ***(K.B)***
(A) Negative charge carriers (B) Neutral charge
(C) Positive charge carriers (D) Both negative and positive charges carriers.

24. Electrical charges flow from: ***(K.B)***
(A) High to low potential (B) Low to high potential
(C) Both a and b (D) None of these

EXAMPLE 14.1

If 0.5 C charge passes through a wire in 10s, then what will be the value of current flowing throuhg the wire? ***(A.B+U.B)***

Solution:

Given data:

Amount of charge = Q = 0.5 C

Time = t = 10 s

To Find:

Value of current = I = ?

Formula:

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

Calculation:

By using formula, we have

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

$$I = \frac{0.5C}{10s} = 0.05A \Rightarrow 50mA$$

Result:

Hence, the value of current flowing through the wire is 50 mA.

14.2 POTENTIAL DIFFERENCE
14.3 ELECTROMOTIVE FORCE (e.m.f)

LONG QUESTIONS

Q.1 Define and explain the potential difference. ***(K.B+U.B+A.B)*** ***(LHR 2014)***

Ans:

POTENTIAL DIFFERENCE

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 *B*.

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 agency which provides the potential difference for 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 forms i.e. heat and light etc.

When current flows through the conductor, it experiences a resistance in the conductor by collision

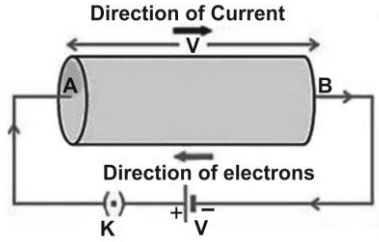


Figure: Potential Difference

with atom of 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 light bulb.

Unit:

SI unit of potential difference is volt.

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 consumes 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.1 What is mean by electromotive force (e.m.f.)? Write its equation and explain its unit. ***(K.B+U.B+A.B)***

(LHR 2015)

OR What do we mean by the term e.m.f? Is it really a force? Explain.(Review Question 14.3)

Ans:

ELECTROMOTIVE FORCE

Definition:

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

OR

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

Formula:

$$\textbf{e.m.f} = \frac{\textbf{Energy}}{\textbf{Charge}}$$

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

Where E is the e.m.f., W is energy converted from non-electrical forms to electrical form and Q is a positive charge.

Unit of e.m.f:

The unit for e.m.f. is JC-1 which is equal to volt (V) in SI system.

Explanation:

When a conductor is connected to a battery, current flows through it due to potential difference. For the continuous flow of current through a wire, battery supplies energy to the charges. The positive charge leaves the positive terminal of the battery, passes through the conductor and reaches the negative terminal of the battery. As a positive charge enters the battery at its lower potential point (negative terminal), the battery must supply energy, say W to the positive charge to drive it to a point of higher potential i.e., positive terminal.

Sources of e.m.f: **(LHR 2013)**

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.

Q.2 How we measured the potential difference and e.m.f across a circuit?

Ans: **MEASUREMENT OF POTENTIAL DIFFERENCE**

The potential difference across a circuit component (e.g., light bulb) can be measured by a voltmeter connected directly across the terminal of the component. The positive terminal of the battery is connected to the positive terminal of the voltmeter and the negative terminal of the battery is connected to the negative terminal of the voltmeter.

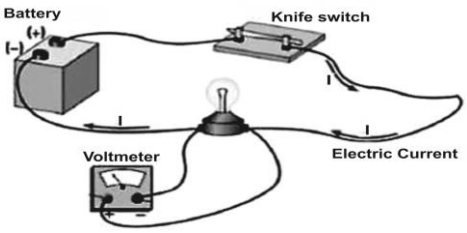


Figure: Schematic Diagram for Measuring Potential Difference in a Circuit

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.

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.

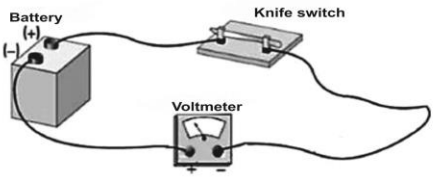
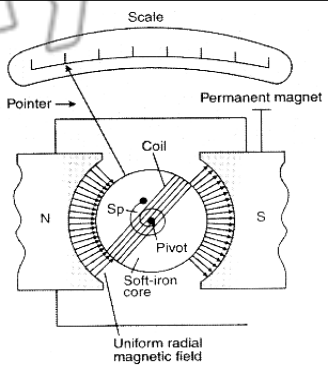


Figure: Schematic Diagram for Measuring e.m.f. of the Battery

14.3 SHORT QUESTIONS

Q.1 What is galvanometer? ***(K.B)***

Ans: A galvanometer is very sensitive instrument and can detect a small current in a circuit. A current of few milliamperes is sufficient to cause full scale deflection in it. 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 with black colour shows the negative polarity. An ideal galvanometer should have very small resistance to pass the maximum current in the circuit.



This Fig. has analogy with topic 15.2 and 15.3

Q.2 Construction and working of galvanometer. ***(Conceptual Base+A.B)***

Ans: The galvanometer consist of light coil of wire suspended from a metallic ribbon between the poles of a permanent magnet. The magnetic filed produced by a current passing through the coil reacts with the magnetic filed of permanent magnet, producing a torque, or twisting magnetic force. The coil, to which an indicating needle is attached is rotates under the action of torque and indicate electric current.

Q.3 What is Ammeter? ***(K.B)***

Ans: An ammeter is a measuring instrument used to measure the direct current and alternating current in a circuit. The ammeter is usually connected in series with the circuit in which the current is to be measured. An ammeter usually has low resistance so that it does not cause a significant voltage drop in the circuit being measured. It used to measure a large range of current between **1 A or 10 A.**

Q.4 What is voltmeter? ***(K.B)***

Ans: A voltmeter is an instrument used for measuring electric **potential difference** between two points in an electric circuit it is connected in **parallel**. It usually has a high resistance so that it takes negligible current from the circuit.

Q.5 What is difference between Ammeter and Voltmeter? ***(K.B)***

Ans: **DIFFERENCE**

Ammeter	Voltmeter
• Ammeter is used to measure the electric current in electric circuit. • It is connected in series along with the circuit. • It has very low resistance so that the current flow through ammeter is maximum and potential drop is also maximum.	• Voltmeter is used to measure the potential difference or e.m.f. a cross to point in a electric circuit. • It is connected in parallel along with the circuit. • It has very high resistance so that the current flow through the voltmeter is minimum and potential drop is also minimum and can be measured.

Q.6 How a galvanometer is converted into voltmeter? ***(U.B)*** **(LHR 2014, GRW 2014, 2015)**

Ans: **CONVERSION OF GALVANOMERTER INTO VOLTMETER**

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 Why resistance of the ammeter is kept low? ***(K.B+U.B)***

OR How a galvanometer is converted into ammeter?

Ans: **CONVERSION OF GALVANOMERTER INTO AMMETER**

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. Hence, it protects the galvanometer from burning.

Q.8 Why resistance of the voltmeter is kept high? ***(K.B+U.B)***

Ans: **HIGH RESISTANCE OF VOLTMETER**

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. Hence, resistance of voltmeter is kept high.

Q.9 On what factor reliability of voltmeter depend? *(U.B+K.B)*

Ans:

RELIABILITY OF VOLTMETER

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.10 How can we differentiate between electromotive force and potential difference? *(K.B)*

(Review Question 14.4)

Ans:

DIFFERENTIATION

The differences between electromotive force and potential difference are as follows:

Potential Difference(V)	Electromotive Force(e.m.f)
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.	• It is the energy supplied by a battery to a unit positive charge when it flows through the closed circuit.
Formula	
• ΔV=(Energy supplied by the charge)/q_0	• e.m.f.=Energy supplied by a battery /Charge
Connection	
• It is across the ends of the conductors	• It is across the terminals of the battery.

Q.11 What is the difference between a cell and a battery? *(K.B+Conceptual Base)*

(LHR 2017)(Conceptual Question 14.2)

Ans:

DIFFERENTIATION

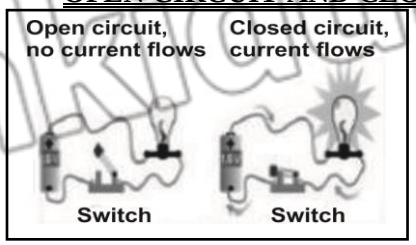
The differences between electromotive force and potential difference are as follows:

Cell	Battery
Definition	
• A cell is a device which converts chemical energy into electrical energy.	• A battery is a combination of no. of cells connected in series.
No. of Electrode	
• It has two electrodes. One is cathode and other is anode.	• It has many electrode but in even numbers. i.e. 4, 6, 8 and so on.
Voltage	
• Voltage of a cell is the potential difference of the both electrodes and is always less than the voltage of a battery.	• Voltage of the battery is the sum of the voltages of the individual cell and always greater than voltage of each individual cell.
Charging	
• They may or may not charge.	• They are chargeable.

Q.12 Draw diagram of open circuit and closed circuit. ***(K.B)***

Ans:

OPEN CIRCUIT AND CLOSED CIRCUIT



Q.13 What is digital multimeter? ***(K.B)*** **(For your information Page # 96)**

Ans:

MULTIMETER

Definition:

"A digital multimeter can be used to measure current, resistance and potential difference**"**. The multimeter is in voltmeter mood to measure the potential difference across a battery.

Q.14 Galvanometer named after which scientist? And which chance discovery, the invention of the chemical cell and the battery? ***(K.B)*** **(Do you know Pg. # 94)**

Ans:

CHANCE DISCOVERY

The galvanometer has been named after Luigi Galvano (1737-1798). He, while dissecting a frog's leg, discovered that dissimilar metals touching the leg cause it to twitch. This chance discovery, the invention of the chemical cell and the battery.

Q.15 Volt is name after which physicist? And who developed the first practical electric battery? ***(K.B)*** **(Do you know Pg. # 95)**

Ans:

FIRST PRACTICAL ELECTRIC BATTERY

The volt is named after the Italian physicist Alessandro Volta (1745-1827), who developed the first practical electric battery, known as a voltaic pile. Because potential difference is measured in units of volts, it is sometimes referred to as voltage.

Q.16 In which cell chemical energy changes into electrical energy? ***(K.B)***

(For your information Pg. # 95)

Ans:

ENERGY

In a dry cell chemical energy changes into electrical energy.

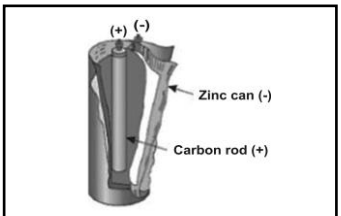


Figure: Dry Cell

14.3 MULTIPLE CHOICE QUESTIONS

1. The energy To Find to move a charge from one point to another in the circuit is called: *(K.B)*

(A) e.m.f (B) Potential difference
(C) Resistance (D) Volt

2. Volt is a unit of: *(K.B)*

(A) Potential difference (B) e.m.f
(C) Potential difference and e.m.f. (D) None of these

3. The energy supplied in driving one coulomb of charge round a complete circuit in which the cell is connected is called: *(K.B)*

(A) e.m.f (B) Potential difference
(C) Resistance (D) Volt

4. The instrument with which we can detect the presence of current in a circuit is knows as: *(K.B)*

(A) Voltmeter (B) Ammeter
(C) Galvanometer (D) Ohm meter

5. In order to detect the current, galvanometer is connected: *(K.B)*

(A) In parallel (B) In series
(C) May be parallel or in series (D) Any where in the circuit

6. If the needle of galvanometer shows some deflection, it would indicate the: *(K.B)*

(A) Presence of current (B) Absence of current
(C) A large current (D) None of these

7. A galvanometer is a very: *(K.B)*

(A) Large instrument (B) Small instrument
(C) Insensitive instrument (D) Sensitive instrument

8. A resistance which is connected with the galvanometer in order to convert it into ammeter should have: *(K.B)*

(A) High resistance (B) Very high resistance
(C) Low resistance (D) Very low resistance

9. The resistance of an ammeter should be: *(K.B)*

(A) Height (B) Very high
(C) Low (D) Very low

10. In order to measure the current in a circuit, ammeter should be connected: *(K.B)*

(A) Parallel to battery (B) In series in the circuit
(C) May be parallel or in series (D) None of these

11. When ammeter is connected in the circuit, the positive terminal of ammeter should be connected with the? *(K.B)*

(A) Negative terminal of the battery (B) Positive terminal of the battery
(C) Any terminal of the battery (D) None of these

12. The potential difference can be directly measured by the instrument known as: ***(K.B)***

(A) Ammeter (B) Potentio-meter
(C) Voltmeter (D) Ohm meter

13. Voltmeter is always connected in a circuit in: ***(K.B)***

(A) Series (B) Parallel
(C) May be in series or parallel (D) None of these

14. A good voltmeter is that which draws: ***(K.B)***

(A) No current (B) Small current
(C) Large current (D) Very large current

16. A galvanometer has been named after: ***(K.B)***

(A) Luigi Galvano (B) Ampere
(C) Ohm (D) None of these

17. The unit of potential difference is named after: ***(K.B)***

(A) Alessandro Volta (B) Christian Volta
(C) Ohms (D) None of these

14.4 OHM'S LAW

LONG QUESTIONS

Q.1 States and explain Ohm's law. What are its limitation? ***(K.B+U.B+A.B)***

(GRW 2014)(Review Question 14.5)

Ans: **OHM'S LAW**

Statement:

The amount of current passing through a conductor is directly proportional to the potential difference 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.

$V \propto I$ or $I \propto V$

$V = (\text{Constant}) I$

$V = (R)I$

$V = IR$……..(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**"**.

Reason:

This opposition comes from the collisions of moving electrons with atoms of the substance.

Unit:

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

Example:

If **V = 1 V**, and **I = 1 A**, the value of **R** will be **1Ω**.

Ohm:

"When a potential difference of one volt is applied across the ends of a conductor and one ampere of current passes through 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.

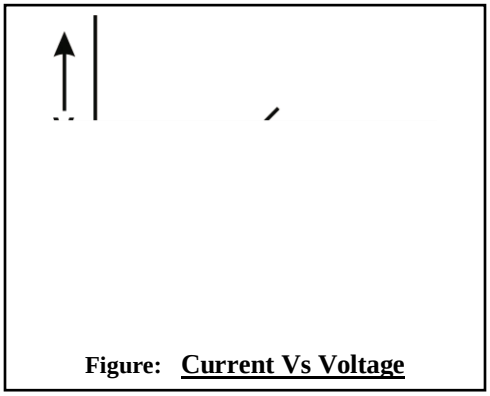


Figure: Current Vs Voltage

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.

Q.2 Verify the ohm's law with the help of an experiment. *(U.B+A.B)*

Ans: **EXPERIMENT**

Take a nichrome wire of about 50 cm length and apply a potential difference of 1.5 V form a battery (a). Measure the current flowing through the wire using an ammeter connected to it in series. Also measure the potential difference across the wire using a voltmeter connected across it. Obtain a set of readings for I and V, by increasing the number of cells. Plot a graph between I and V. This will be a straight line (b).

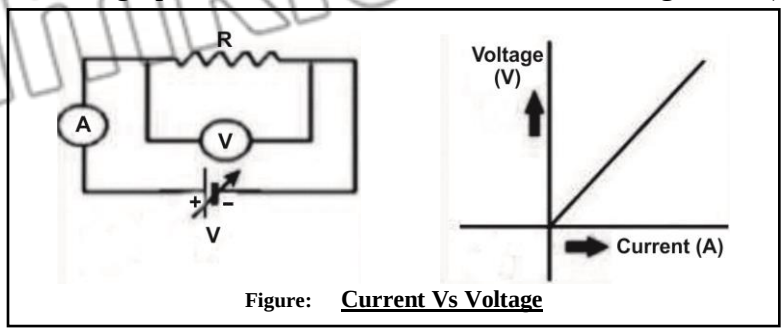


Figure: Current Vs Voltage

Conclusion:

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

14.4 SHORT QUESTIONS

Q.1 State and explain Ohm's law. Write down its limitations. *(K.B+U.B)*
(LHR 2016, GRW 2015, 2016)

Ans: ***Given on Page # 218***

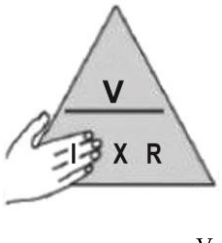
Q.2 Define resistance and its unit. *(K.B)* **(LHR 2014, 2016)(Review Question 14.6)**

Ans: ***Given on Page # 219***

Q.3 What is an easy method of learn relation between potential (V), current (I) and resistance (R) with the help of a figure. *(K.B+U.B)* **(Physics insights Pg. # 98)**

Ans: **EASY METHOD TO LEARN**

An easy method to learn the relation between potential (V), current (I) and resitance (R) is shown by the figure given below:



Cover *I* to find $I = \frac{V}{R}$

Q.4 Write down the uses of voltmeter and ammeter. *(A.B)* (For your information Pg. # 98)

Ans: **USES OF VOLTMETER AND AMMETER**

In order to measure current through a resistance, ammeter is always connected in series with the resistance. In order to measure potential difference across a resistance, voltmeter is always connected in parallel with the resistance.

14.4 MULTIPLE CHOICE QUESTIONS

1. The relation V = IR represents: *(U.B+A.B)*

(A) Ampere law (B) Coulomb's law
(C) Faraday's law (D) Ohm's law

2. Ohm's law is applicable to: *(A.B)*

(A) Liquids only (B) Gases only
(C) Liquid conductors only (D) Metallic conductors only

3. Ohm is the unit of: *(K.B)*

(A) Current (B) Capacitance
(C) Electric intensity (D) Resistance

4. Ohm is defined as: ***(U.B)***

(A) Volt/Coulomb or VC^{-1} (B) Volt/Ampere or VA^{-1}
(C) Ampere/Volt or CV^{-1} (D) Ampere/Volt or AV^{-1}

5. 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: ***(U.B)***

(A) One volt (B) One coulomb
(C) One Ohm (D) One ampere

6. The graphical representation of Ohm's law is: ***(K.B)***

(A) Hyperbola (B) Ellipse
(C) Parabola (D) Straight line

7. The value of current passing through a conductor is directly proportional to the: ***(K.B)***

(A) Resistance (B) Capacitance
(C) Potential difference (D) None of these

8. The property of a substance which opposes the flow of current through it is called: ***(K.B)***

(A) Conductivity (B) Capacitance
(C) Resistance (D) Conduction

9. 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? ***(U.B+A.B)***

(A) 210Ω (B) 440Ω
(C) 880Ω (D) 110 ohm

10. The series resistance which is connected with galvanometer to convert it into voltmeter usually has value in: ***(K.B)***

(A) Ohms (B) Several hundred ohms
(C) Several thousand ohms (D) Hundred thousand ohms

EXAMPLE 14.2

Reading on voltmeter connected across a heating element is 60 V. The amount of current passing through the heating element measured by an ammeter is 2A. What is the resitstance of the heating coil of the element? ***(U.B+A.B)***

Solution:

Given data:

Voltmeter reading (potential) = V = 60 V

Ammeter readint (current) = I = 2A

To Find:

Resistance of heating coil = R = ?

Formula:

$V = IR$

Calculation:

By using formula, we have

$V = IR$

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

Or $R = \frac{60V}{2A} = 30VA^{-1} \Rightarrow 30\Omega$

Result:

Hence, the resistance of heating coil of the element will be 30Ω

14.5 CHARACTERISTICS OF OHMIC AND NON OHMIC CONDUCTORS

LONG QUESTIONS

Q.1 Explain the V-I characteristics of Ohmic and non Ohmic conductor. ***(K.B+A.B)***

Ans:

OHMIC CONDUCTORS

Definition:

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

V-I Characteristics of Ohmic Conductor:

Ohmic conductors have a linear current-voltage relationship over a large range of applied voltages. The straight line shows a constant ratio between voltage and current, So Ohm's law is obeyed.

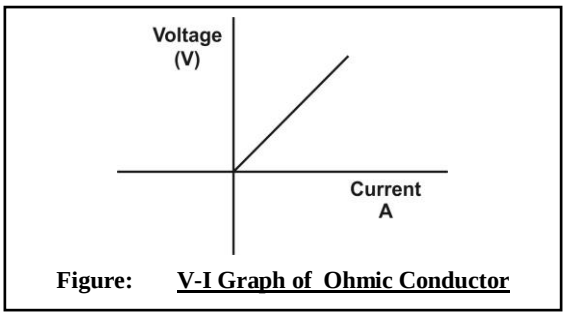


Figure: V-I Graph of Ohmic Conductor

Example:

Most metals show ohmic behavior.

NON-OHMIC CONDUCTOR

Definition:

"Materials having resistance that changes with voltage or current are non-ohmic**"**.

V-I Characteristics of Non-Ohmic Conductor:

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

Example:

- Filament lamp
- Thermister

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.

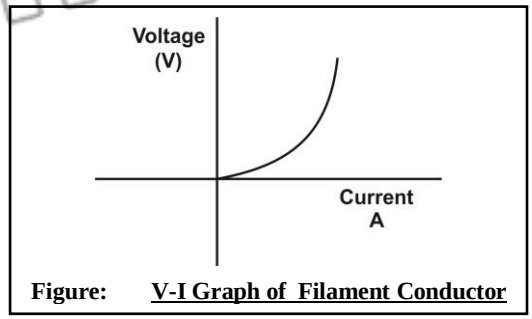


Figure: V-I Graph of Filament Conductor

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.

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

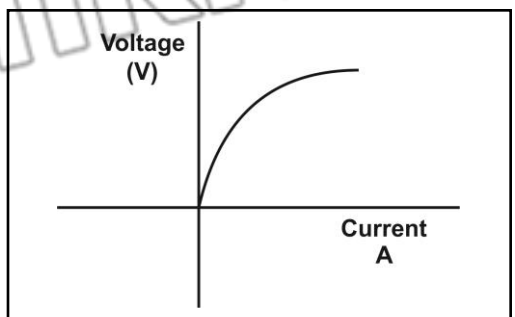


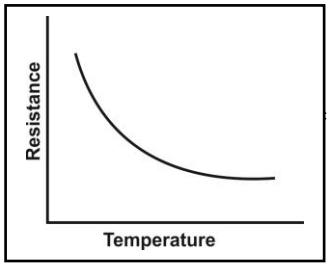
Figure: V-I Graph of Thermister

14.5 SHORT QUESTIONS

Q.1 Define Ohmic conductors. ***(K.B)***

Ans: ***Given on Page # 222***

Q.2 Define thermister. ***(K.B+A.B)*** **98)**



Ans: **THERMISTER**

Definition:

"A thermister (a heat sensitive resistor) behaves in the opposite way because thermistor is made up of semi conductor of material. Its resistance decreases (current increases) as its temperature rises**"**.

Use:

Thermister is used in a circuit that senses temperature changes.

Q.3 Define non-ohmic conductors. ***(K.B)***

Ans: ***Given on Page # 222***

Q.4 The current versus voltage graph of a resistor is a straight line with a constant slope. The graph of a light bulb is curved with a decreasing slope. What can you infer from this? ***(K.B)***

(Point to ponder Pg. # 99)

Ans: **GRAPH OF OHMIC & NON-OHMIC CONDUCTOR**

The resistor which has straight line graph with constant slope obeys Ohm's law and called as ohmic conductor. While the light bulb having curved graph does not obey Ohm's law and called as non-ohmic conductor.

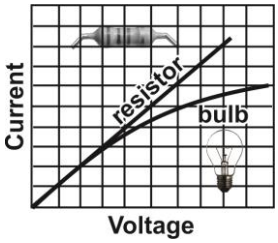


Figure: Graph of Ohmic & Non-Ohmic Conductor

Q.5 Define Resistance and its effect on temperature of conductor. ***(Conceptual Base)***

Ans: There is a heating effect whenever a current flows in a resistance. This principle is used in heating elements, and also in light lamps with filaments. The heating effect occurs because electrons collide with atoms as they pass through a conductor. The electrons lose energy. The atoms gain energy and vibrate faster. Faster vibrations mean a higher temperature.

14.5 MULTIPLE CHOICE QUESTIONS

1. Thermistor is: ***(K.B)***

(A) A heat sensitive resistor (B) potential divider
(C) constant resistor (D) An ordinary resistor

2. Materials that obey Ohm's law have constant: ***(K.B)***

(A) Resistance (B) Voltage
(C) Current (D) None of these

3. Materials having resistance that changes with voltage or current are called: ***(K.B)***

(A) Ohmic conductor (B) Non-Ohmic conductor
(C) Both a and b (D) None of these

4. The shape of the graph of Ohmic conductor is: ***(K.B)***

(A) Parabola (B) Straight line
(C) Circular (D) Both a and b

5 The shape of the graph of Ohmic conductor is: ***(K.B)***

(A) Non-linear (B) Linear
(C) Both a and b (D) None of these

14.6 FACTORS AFFECTING RESISTANCE

LONG QUESTIONS

Q.1 Define and explain the term specific resistance. Discuss different factors which affect the resistance of conductors. ***(K.B+A.B+U.B)*** **(GRW 2014)**

Ans:

SPECIFIC RESISTANCE

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 the resistance of wire that carry current .the resistance of wire depends both on the cross-sectional area and length of the wire on the nature of the material of the wire.

Factors:

At specific temperature resistance depends upon the following factors.

- Length of conductor
- Cross-sectional area of conductor
- Nature of the conductor

Derivation of Specific Resistance:

At a certain temperature and for a particular substance resistance depends upon the following factors.

Length and Resistance:

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

$$\mathbf{R \propto L \rightarrow (i)}$$

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.

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.

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

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:

If $\mathbf{L = 1\ m}$ and $\mathbf{A = 1m^2}$ then $\mathbf{R = \rho}$ i.e., the resistance of one meter cube of a substance is equal to its specific resistance. According to above equation the unit of $\boldsymbol{\rho}$ is ohm-meter **(Ωm)**.

14.6 SHORT QUESTIONS

Q.1 What are the factors upon which the resistance of a conductor depends? ***(K.B)*** **(GRW 2016)**

Ans: ***Given on Page # 224***

Q.2 Write down the specific resistance of the following metals: ***(K.B)***

- **Silver**
- **Copper**
- **Aluminum**
- **Tangston**
- **Platinum**
- **Iron**
- **Nichrome**
- **Graphite**

Ans: **SPECIFIC RESISTANCE**

Specific resistance of metals are given in the following table.

(Table for MCQs)

Metal	Specific resistance ($10^{-8}\Omega$ m)
Silver	1.7
Copper	1.69
Aluminium	2.75
Tungsten	5.25
Platinum	10.6
Iron	9.8
Nichrome	100
Graphite	3500

Q.3 Upon which factor does resistivity depend? ***(K.B)***

Ans: **DEPENDENCE OF RESISTIVITY**

Its value depends upon the nature of conductor i.e., copper, iron, tin, and silver would each have a different values of '**ρ**'.

Q.4 Why does the resistance of a conductor increase with the rise of its temperature? ***(K.B+U.B)***

Ans: **EFFECT OF TEMPERATURE ON RESISTANCE**

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.

14.6 MULTIPLE CHOICE QUESTIONS

1. The resistance of a meter cube of the substance is called: ***(K.B)***

(A) Conductivity (B) Permittivity
(C) Resistivity (D) Susceptibility

2. At a certain temperature, the resistance of a wire is directly proportional to its: ***(K.B+U.B)***

(A) Length (B) Area of cross-section
(C) Shape (D) Colour

3. At a certain temperature, the resistance of a wire is inversely proportional to its: ***(K.B+U.B)***

(A) Length (B) Area of cross-section
(C) Temperature (D) Colour

4. If we increase the length of a wire to four times of its original length, what will be its resistance? ***(K.B+U.B)***

(A) The same (B) Doubled
(C) Four times (D) Eight times

5. If we increase the cross-sectional area of the wire to double of its original area, its resistance will become: ***(K.B+U.B)***

(A) The same (B) Halved
(C) One fourth (D) Doubled

6. If L is the length and A is the cross-sectional area of a wire, then its resistance is gives by the relation: ***(K.B+U.B)***

(A) $R = \frac{1}{\rho}\frac{L}{A}$ (B) $R = \frac{1}{\rho}\frac{A}{L}$
(C) $R = \rho\frac{A}{L}$ (D) $R = \rho\frac{L}{A}$

7. The SI unit of specific resistance is: ***(K.B)***

(A) $\Omega - m^2$ (B) $\Omega - m$
(C) $\Omega - m^{-1}$ (D) $\Omega - m^{-2}$

8. If we increase the temperature of a conductor, its resistance will: ***(U.B)***

(A) Increase (B) Decrease
(C) Remains the same (D) None of these

9. The resistance of a conductor does not depend on its: ***(K.B)***

(A) Length (B) Cross sectional area
(C) Resistivity (D) Mass

EXAMPLE 14.3

If the length of copper wire is 1m and its diameter is 2mm, then find the resistance of this copper wire. ***(A.B+U.B)*** **(LHR 2017)**

Solution:

Given Data:

Length of copper wire = L = 1m

Diameter of copper wire = d = 2mm

Specific resistance of copper = $\rho = 0.54\times10^{-4}\Omega m$

To Find:

Resistance of copper wire = R = ?

Formula:

$$A = \frac{\pi \times d^2}{4} \text{ ……(1)}$$

$$R = \frac{\rho \times L}{A} \text{ ……..(2)}$$

Calculation:

Putting the values from given data in the formula (1)

$$A = \frac{3.14 \times (2\times10^{-3})^2}{4}$$

$$A = 3.14\times10^{-6} m^2$$

Putting the values from given data in the formula (2)

$$R = \frac{1.69\times10^{-8}\times1}{3.14\times10^{-6}}$$

$$R = 5.4\times10^{-3}\Omega$$

Result:

Hence, resistance of copper wire is $5.4\times10^{-3}\Omega$

14.7 CONDUCTORS
14.8 INSULATORS

LONG QUESTIONS

Q.1 What is the difference between the conductors and insulators? ***(K.B)***

(LHR 2016)(Review Question 14.7)

Ans: **DIFFERENTIATION**

The differences between the conductors and insulators are as follows:

Conductors	Insulators
Definition	
• The substances which conduct electricity and heat are called conductors.	• The substances which do not conduct electricity and heat is called non-conductors or insulators.
Examples	
• All metals are conductor • Graphite is also a conductor	• Wood • Plastic • Rubber
Free Electrons	
• It has free electrons which are responsible of conduction.	• It has no free electrons
Graph	
• Its I-V graph is linear	• Its I-V graph is curved.

14.7 SHORT QUESTIONS

Q.1 Why do we always use metal wires for conduction of electricity? ***(K.B+U.B+A.B)***

Ans: **USE OF METALLIC WIRES FOR CONDUCTION**

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.2 What do you mean by insulators? ***(K.B)***

Ans: **INSULATRORS**

Definition:

"The substances through which almost no current flow are called insulators**"**.

Insulators have very large value of resistance. Insulators can be easily charged by friction and the induced charged remains static on their surface.

Examples:

- Glass
- Wood
- Plastic
- Fur
- Silk

Q.3 Why insulator are non-conductors of electricity? ***(K.B)***

Ans: **NON-CONDUCTOR OF EELCTRICITY**

The insulators are non-conductors of electricity because electrons are not free to move their tightly bound inside atoms

Q.4 Why metals are good conductors of electricity? ***(K.B)***

Ans: **METALS ARE GOOD CONDUCTORS**

Metals are good conductors of electricity because they have excess of free electrons which are not held strongly with any particular atom of metal. These free electrons move randomly in all direction inside metals. When we apply external electric field these electrons can move easily move in specific direction. This movement of free electrons in a particular direction under the influence of an external field causes the flow of current in metal wires.

Q.5 How can a jeweler tell about a fake and real diamond? ***(K.B+U.B)***

(Interesting Information Pg. # 100)

Ans: **REAL OR FAKE DIAMOND**

Diamond does not conduct electricity, because it has no free electrons. However, it is very good at conducting heat because its particles are very firmly bonded together. Jewellers can tell if a diamond is a real diamond or a fake one made from glass, by holding it to their lips. A real diamond feels very cold due to good ability of transferring heat four or five times better than copper.

14.7 MULTIPLE CHOICE QUESTIONS

1. When the temperature of a conductor is raised, its resistance: ***(K.B)***

(A) Always decreases (B) Always increases

(C) Remains the same (D) First increases and then decrease

2. The electrons in the insulator are: ***(K.B)***

(A) Loosely bounded (B) Tightly bounded

(C) Both a and b (D) None of these

3. The electrons in the conductor are: ***(K.B)***

(A) Loosely bounded (B) Tightly bounded

(C) Both a and b (D) None of these

4. Who are responsible for the conduction of electricity conductor? ***(K.B)***

(A) Negative ions (B) Positive ions

(C) Free electrons (D) All of these

5. In the absence of external source, electrons of the conductor move: ***(K.B)***

(A) Randomly (B) Unidirectional

(C) Stationary (D) All of these

14.9 COMBINATION OF RESISTOR

LONG QUESTIONS

Q.1 How 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. ***(K.B+U.B+A.B)*** **(LHR 2017)**

OR Determine the equivalent resistance of series combination of resistors. **(Review Question 14.11)**

Ans:

SERIES COMBINATION

Definition:

"In series combination, resistors are connected end to end and electric current has a single path through the circuit. This means that the current passing through each resistor is the same**"**.

Characteristics of Series Combination:

The total voltage in a series circuit divides among the individual resistors so the sum of the voltage across the resistance of each individual resistor is equal to the total voltage supplied by the source. Thus, we can write as:

$$V = V_1 + V_2 + V_3$$

Where V is the voltage across a battery, and V_1, V_2 and V_3 are the voltages across resistors R_1, R_2 and R_3 respectively.

If I is the current passing through the resistors, then from Ohm's law

$$V = IR_1 + IR_2 + IR_3$$

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

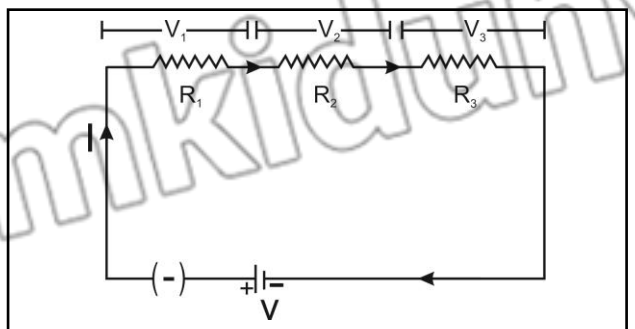


Figure: Series Combination of Resistors

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 passes through the circuit. The equivalent resistance Re. 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

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

$$R_e = R_1 + R_2 + R_3$$

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.

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

Conclusion:

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

Q.2 How 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. ***(K.B)*** **(GRW 2015, LHR 2014, 2015, 2017)**

OR Discuss the main features of parallel combination of resistors. **(Review Question 14.10)**

Ans: **PARALLEL COMBINATION**

Definition:

In parallel combination one end of each resistor is connected with positive terminal of battery while the other end of each resistor is connected with the negative terminal of battery.

The voltage is same across each resistor which is equal to the voltage of the battery i.e.,

$$V = V_1 = V_2 = V_3$$

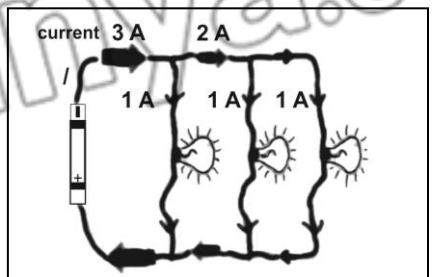


Figure: Parallel Circuit Current Divides into Branches

Features of Parallel Combination:

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.

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

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

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

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

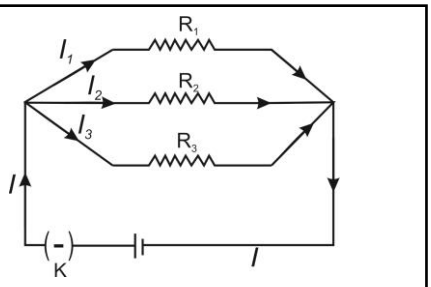


Figure: Parallel Combination of Resistors

The combination of resistors can be replaced with a single resistor called the equivalent resistors R_e. 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.

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

Conclusion:

Thus, the reciprocal of equivalent resistance of a parallel combination is sum of the reciprocals of the individual resistances, which is less than the smallest resistance of the combination.

Advantages of Parallel: **(LHR 2014)**

Parallel circuits have two big advantages over series circuits.

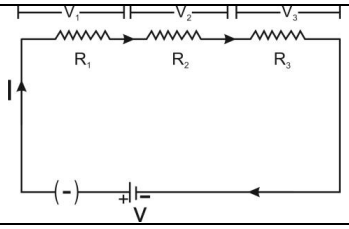
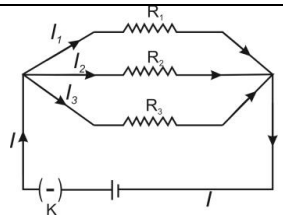
1. Each device in the circuit receives the full battery voltage.
2. Each device in the circuit may be turned off independently without stopping the current flowing to the other devices in the circuit.

This principle is used in household wiring.

Q.3 Differentiate between series combination and parallel combination. ***(K.B)***

Ans: **DIFFERENTIATION**

The differences between series combination and parallel combination are as follows:

Series Combination	Parallel Combination
Definition	
• In series combination, resistors are connected end to end and electric current has a single path through the circuit. This means that the current passing through each resistor is the same.	• In parallel combination one end of each resistor is connected with positive terminal of battery while the other end of each resistor is connected with the negative terminal of battery.
Diagram	
	
Voltage	
• $V = V_1+V_2+V_3$	• $V_1= V_2= V_3$
Current	
• $I_1= I_2= I_3$	• $I = I_1+I_2+I_3$
Equivalent Resistance	
• The equivalent resistance of a series combination is equal to the sum of the individual resistances of the combinations and is always greater than the resistance of individuals. $R_e = R_1 + R_2 + R_3 + \ldots + R_n$	• The reciprocal of equivalent resistance of a parallel combination is sum of the reciprocals of the individual resistances, which is less than the smallest resistance of the combination. $\frac{1}{R_e}=\frac{1}{R_1}+\frac{1}{R_2}+\frac{1}{R_3}+\ldots\frac{1}{R_n}$

14.9 SHORT QUESTIONS

Q.1 What are the advantages of parallel combination over series combination? ***(K.B+A.B)***

Ans: **ADVANTAGES OF PARALLEL COMBINATION**

Parallel circuits have two big advantages over series circuits.

- Each device in the circuit receives the full battery voltage.
- Each device in the circuit may be turned off independently without stopping the current flowing to the other devices in the circuit. This principle is used in household wiring.

Q.2 Which metal is used as the filament of an electric bulb? Explain with reason. ***(K.B)*** **(Quick Quiz Pg. # 101)**

Ans: **METAL USED IN FILAMENT**

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

Q.3 What do you know about a circuit diagram? ***(K.B)*** **(For your information Pg. # 103)**

Ans: **CIRCUIT DIAGRAM**

Definition:

"A circuit diagram is a symbolic method of describing a real circuit. The electric symbols used in circuit diagrams are standard, so anyone familiar with electricity can interpret a circuit diagram**"**.

Q.4 How can you determine the overall resistance of all the resistors having same resistance connected in parallel combination? ***(U.B)*** **(For your information Pg. # 104)**

Ans: **OVERALL RESISTANCE**

If the values of all the resistors in a parallel circuit are the same, the overall resistance can be determined by:

$$\frac{1}{R_e} = \frac{N}{R} \text{ i.e. } R_e = \frac{R}{N}$$

Where N is the total number of resistors and R is the resistance of each individual resistor.

Q.5 What would be the effect on the brightness of three bulbs connected in parallel to a small 2.5 V battery? Does the brightness of the bulbs differ from the bulbs connected in the series with the battery? Explain. ***(K.B+U.B)*** **(Activity 14.2 Pg. # 104)**

Ans: **EFFECTS ON BRIGHTNESS**

- Connecting batteries in parallel will not change the voltage but as we go on increasing the number of bulbs in parallel, the resistance of circuit decreases so current drawn from battery will increase which will drain out battery quickly but brightness of bulbs in parallel combination will remain same as long as battery does not sun short of some threshold level of energy.
- In series combination as potential will divide so current will also decrease on increasing resistance hence brightness will decrease.

14.9 MULTIPLE CHOICE QUESTIONS

1. The resistances are connected end to end and provide only one path for current in: ***(K.B)***

(A) Parallel circuit (B) Series circuit
(C) Both parallel and series circuit (D) None of these

2. The potential drop across each of resistors will be same in: ***(K.B)***

(A) (B) Series circuit
(C) Both parallel and series circuit (D) None of these

3. In series circuit, the magnitude of current that flows through each resistor is: ***(K.B)***

(A) Very small (B) Very large
(C) Same (D) Different

4. In parallel circuit, the magnitude of current that flows through each resistor will be: *(K.B)*

(A) Very small (B) Very large

(C) Same (D) Different

5. In series combination of resistors, the expression of equivalent voltage is given by: *(U.B+A.B)*

(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) $\frac{1}{V} = \frac{1}{V_1} + \frac{1}{V_2} + \frac{1}{V_3}$

6. The equivalent resistance for series combination of 3 resistors is given by: *(U.B+A.B)*

(A) $\frac{1}{\mathrm{R_e}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$ (B) $\frac{1}{\mathrm{R_e}} = \frac{V}{R_1} + \frac{V}{R_2} + \frac{V}{R_3}$

(C) $\mathrm{Re} = R_1 + R_2 + R_3$ (D) $\mathrm{R_e} = VR_1 + VR_2 + VR_3$

7. The equivalent resistance for parallel combination of 3 resistors is given by: *(U.B+A.B)*

(A) $\frac{1}{\mathrm{R_e}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$ (B) $\frac{1}{\mathrm{R_e}} = \frac{V}{R_1} + \frac{V}{R_2} + \frac{V}{R_3}$

(C) $\mathrm{Re} = R_1 + R_2 + R_3$ (D) $\mathrm{R_e} = VR_1 + VR_2 + VR_3$

8. The expression for total current through parallel combination is: *(U.B+A.B)*

(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) $I = 2_1 - 2I_2 - 2I_3$

9. If three resistances of $6\,\Omega$ each are connected in series combination, what will be the equivalent resistance? *(U.B+A.B)*

(A) $6\,\Omega$ (B) $12\,\Omega$

(C) $18\,\Omega\,\mathrm{Q}$ (D) $24\,\Omega$

10. When resistors are connected in series, the equivalent resistance is equal to? *(K.B)*

(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 resistan1ce

11. If the resistors are connected in parallel, then: *(K.B)*

(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

12. If the resistance of 2 ohm and 4 ohm are connected in parallel, the equivalent resistance will be: *(U.B+A.B)*

(A) 11.0 ohms (B) 1.33 ohms

(C) 3.0 ohms (D) 5.0 ohms

13. Three resistance 5000, 500 and 50 ohms are connected in series across 555 volts mains. The current flowing through them will be: *(U.B+A.B)*

(A) 1A (B) 100 mA

(C) 10 mA (D) 10A

EXAMPLE 14.4

If two resistors of $6k\Omega$ and $4k\Omega$ are connected in series across a 10 V battery, then find the follwoing quantities. *(U.B+A.B)*

(a) Equivalent resistnace of the series combination

(b) The current flowing through each of the resistance

(c) Potential difference across each of the resistances

Solution:

Given data:

Resistnace of 1st resistor $= R_1 = 6k\Omega$

Resistance of 2nd resistor $= R_2 = 4k\Omega$

Voltage of battery = V = 10 V

To Find:

(a) Equivalent resistnace of the series combination = ?

(b) The current flowing through each of the resistance = ?

(c) Potential difference across each of the resistances = ?

Formula:

(a) $R_e = R_1 + R_2$

(b) $I = \dfrac{V}{R_e}$

(c) $V_1 = IR_1$ and $V_2 = IR_2$

Calculation:

(a) Equivalent resistnace of the series combination

$R_e = R_1 + R_2$

Or $R_e = 6k\Omega + 4k\Omega \Rightarrow 10k\Omega$

(b) The current flowing through each of the resistance

$I = \dfrac{V}{R_e}$

Or $I = \dfrac{10V}{10k\Omega} = \dfrac{10V}{10\times10^3\Omega} = 1.0\times10^{-3}A \Rightarrow 1mA \qquad \therefore (10^{-3} = \text{mili})$

(c) Potential difference across R_1:

By using the formula, we have

$V_1 = IR_1$

Or $V_1 = 1.0 \times 10^{-3} A \times 6k\Omega = 6V$

Potential difference across R_2:

By using the formula, we have

$V_2 = IR_2$

Or $V_2 = 1.0 \times 10^{-3} A \times 4k\Omega = 4V$

Result:

Hence, in series combination of given resistances equivalent resistance, current and potential difference across each resistor will be 10kΩ, 1 mA, 6 V and 4 V respectively.

EXAMPLE 14.5

If in the circuit (Figure), $R_1 = 2\Omega, R_2 = 3\Omega, R_3 = 6\Omega$ and $V = 6V$, then find the following quantities. *(U.B+A.B)*

(a) Equivalent resistance of the circuit

(b) Current passing through each resistance

(c) The total current of the circuit

Solution:

Given data:

Resistance of 1st resistor $= R_1 = 2\Omega$

Resistance of 2nd resistor $= R_2 = 3\Omega$

Resistance of 3rd resistor $= R_3 = 6\Omega$

Voltage of battery = V = 6V

To Find:

(a) Equivalent resistance of the circuit $= R_e = ?$

(b) Current passing through each resistance $= I_1, I_2$ and $I_3 = ?$

(c) The total current of the circuit $= I = ?$

Formula:

(a) $\frac{1}{R_e} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$

(b) $I_1 = \frac{V}{R_1}$, $I_2 = \frac{V}{R_2}$ and $I_3 = \frac{V}{R_3}$

(c) $I = I_1 + I_2 + I_3$

Calculation:

(a) Equivalent resistance of the circuit

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

Or $\frac{1}{R_e} = \frac{1}{2\Omega} + \frac{1}{3\Omega} + \frac{1}{6\Omega}$

Or $\frac{1}{R_e} = \left[\frac{1}{2} + \frac{1}{3} + \frac{1}{6}\right] \times \frac{1}{\Omega} = \frac{6}{6\Omega}$

Or $\frac{1}{R_e} = \frac{1}{1\Omega} \Rightarrow R_e = 1\Omega$

This value is smaller than the lowest value of the resistanc ein the comibination which is always the case in parallel cases.

(b) Current passing through each resistance

In paralle combination, the potential difference across each of the resitance is same and is equal to the potential of the battery, which is 6V. Therefore,

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

Or $I_1 = \frac{6V}{2\Omega} \Rightarrow 3A$

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

$$I_2 = \frac{6V}{3\Omega} \Rightarrow 2A$$

And $I_3 = \frac{V}{R_3}$

$$I_3 = \frac{6V}{6\Omega} \Rightarrow 1A$$

(c) The total current of the circuit

Sum of the currents passing through the resistances in parallel combination is equal to the total current I of the circuit. Therefore,

Total current $= I = I_1 + I_2 + I_3$

Or $I = 3A + 2A + 1A = 6A$

Result:

Hence, the equivalent resistance (R_e), current through each resistor (I_1), (I_2), (I_3) and total current of the circuit will be 1Ω, 3A, 2A, 1A and 6A respectively.

14.10 ELECTRICAL ENERGY AND JOULE'S LAW

LONG QUESTIONS

Q.1 State and explain joule's law. Derive its formula. ***(K.B+U.B+A.B)*** **(LHR 2014)**

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:

Turbine runs generator to produce electrical energy when water falls on it form higher gravitational potential to lower gravitational potential.

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.

Mathematical Formula:

Consider two point with a potential difference of **V** volts. If one coulomb of charge passes between these points. The amount of energy delivered 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**. Electrical energy supplied by **Q** charge.

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

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

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

$$\Rightarrow \quad Q = It \rightarrow \text{(ii)}$$

So the energy supplied by Q charge in t second.

Put eq (ii) in eq (i)

$$W = I \times t \times V \rightarrow \text{(iii)}$$

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

By Ohms law, we have

$$V = IR \rightarrow \text{(iv)}$$

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

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

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

$$W = I^2 Rt = \frac{V^2 t}{R}$$

This equation is called joules law.

Importance:

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

- Bulb converts this energy into light and heat
- Heater and iron convert this heat energy into heat.
- Electric fans convert into mechanical energy.

14.10 SHORT QUESTIONS

Q.1 State Joule's Law. ***(K.B+U.B+A.B)*** **(GRW 2013, LHR 2014, 2017)**

Ans: ***Given on Page # 237***

Q.2 How do we use the heating effect of current for different purposes? ***(A.B)***

(Do you know Pg. # 101)

Ans: **USES OF HEATING EFFECTS**

We use heating effect of an electric current for different purposes.

Examples:

- When a current flows through the filament of a bulb, it glows white hot and gives out light.
- Electric heaters have very thin wires that glow red hot when a current flows.

14.10 MULTIPLE CHOICE QUESTIONS

1. 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.B+U.B)***

(A) $W = \frac{Q}{V}$ (B) $W = \frac{V}{Q}$

(C) $W = QV$ (D) W = F.S

2. If a current I ampere flows through a resistance R in time seconds, then the energy supplied will be: ***(A.B+U.B)***

(A) W = IRt (B) $W = I^2Rt$

(C) $W = IR^2t$ (D) $W = IRt^2$

3. The energy supplied $W = I^2Rt$ is the mathematical expression for: ***(K.B)***

(A) Ohm's law (B) Fleming's law

(C) Faraday's law (D) Joule's law

4. 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: ***(U.B)***

(A) I^2R (B) IRt

(C) Vlt (D) I^2Rt

EXAMPLE 14.6

If a current of 0.5 A passes through a bulb connected across a battery of 6 V for 20 seconds, then find the rate of energy transferred to the bulb. Also find the resistance of the bulb. ***(A.B+U.B)***

Solution:

Given data:

Current passing through a bulb $= I = 0.5A$

Voltage of battery = V = 6 V

Time = t = 20 s

To Find:

(a) Rate of energy transferred = W/t = ?

(b) Resistance of the bulb = R = ?

Formula:

(a) Rate energy transfer = W/t = ?

(b) $W = I^2RT$

Calculation:

(a) Rate energy transfer = W/t = ?

To find the rate of energy transfer, first we have to find energy. SO by using formula, we have

$W = VIt$

Or $W = 6V \times 0.5A \times 20s$

Or $W = 60J$

(b) Resistance of the bulb = R = ?

$W = I^2RT$

Or $R = \frac{W}{I^2 \times t}$

Or $R = \frac{60}{20 \times (0.5)^2} = \frac{60}{20 \times 0.25}$

$R = 12\Omega$

Result:

Hence, the rate of energy transferred to the bulb and resistance of bulb will be 3 watt and 12Ω respectively.

14.11 ELECTRIC POWER

LONG QUESTIONS

Q.1 What is electric power? How it is calculate and write its unit. ***(K.B+A.B+U.B)*** **(LHR 2015, 2016)**

Ans: **ELECTRIC POWER**

Definition:

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

Mathematical Formula:

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

Conclusion:

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 ($1Js^{-1}$). 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.2 What is kilowatt hour? How the cost of electricity in a house can be a calculated? ***(K.B+A.B+U.B)***

Ans: **KILOWATT HOUR**

Definition:

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 = 1 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

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

14.11 SHORT QUESTIONS

Q.1 Define electric power. ***(K.B+U.B+A.B)*** **(LHR 2014)**

Ans: ***Given on Page # 240***

Q.2 Define kilowatt hour? ***(K.B+U.B+A.B)*** **(LHR 2014)**

Ans: ***Given on Page # 240***

Q.3 How will you calculate the cost of electricity? ***(U.B+A.B)***

Ans:

COST OF ELECTRICITY

Cost of electricity can be calculated by the following formula

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

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

Q.4 A light 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. (*U.B+A.B*)

(Self-Assessment Pg. # 107)

Ans:

NUMERICAL

Solution:

Given Data:

Time = t = 40s

Electrical Energy = w = 2400 J

To Find:

Power of the bulb =P = ?

Formula:

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

Calculations:

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

Result:

Hence, power of bulb is 60W.

What information do we get from the power rating of an electrical appliance? ***(K.B)***

(For your information Pg. # 105)

Ans: **POWER RATING OF AN ELECTRICAL APPLIANCE**

All electrical appliances have power rating given in watts or kilo watts. An appliance with a power rating of 1W transfers 1J of electrical energy each second. So a 60W light bulb converts 60J of electrical energy each second into light energy and heat energy. To find out the total energy an appliance transfers from the mains, we need to know the number of joules transferred each second and the number of seconds for which the appliance is ON.

Q.5 How does an energy saver save energy? ***(K.B)***

(For your information Pg. # 105)

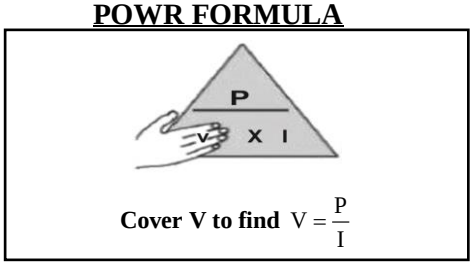
Ans: **ENERGY SAVER**

Energy saver light bulbs transform much more of the electrical energy into light and much less into wasted heat energy. An energy saver light bulb that uses 11J of electrical energy each second gives the same amount of light as an ordinary incandescent bulb that uses 60J of electrical energy each second.

Q.6 Describe the easy method to remember the power formula with help of a figure. ***(K.B)***

(Remembering power formula Pg. # 106)

Ans: **POWR FORMULA**



Cover V to find $V = \frac{P}{I}$

Q.7 What would be the unit of time and power to work out the energy? ***(K.B)***

(Remember Pg. # 107)

Ans: **UNIT OF TIME AND POWER**

To work out the energy transferred, the time must be in seconds and the power in watts.

Q.8 What would be the unit of power and time to work out the cost? ***(K.B)***

(Remember Pg. # 107)

Ans: **UNIT OF TIME AND POWER**

To work out the cost, the power must be in kilowatts and the time must be in hours.

Q.9 Write down the typical power rating of the following appliances. ***(K.B)***

(For your information Pg. # 104)

- **Electric stove**
- **Electric heater**
- **Hair dryer**
- **Iron**
- **Washing machine**
- **Light bulb**
- **Small fan**
- **Clock radio**

Ans: **POWER RATING OF APPLIANCES**

(Table for MCQs)

Appliances	Power (watts)
Electric stove	5,000
Electric heater	1,500
Hair dryer	1,000
Iron	800
Washing machine	750
Light bulb	100
Small fan	50
Clock radio	10

14.11 MULTIPLE CHOICE QUESTIONS

1. The amount of energy supplied by current in unit time is known as: ***(K.B)***

(A) Electrical energy (B) Electrical power

(C) Electrical work (D) Potential difference

2. When current I is flowing through a resistance R the electrical power that generates heat in the resistance is given by: ***(U.B)***

(A) IR (B) I/R

(C) I^2R (D) IR^2

3. The SI unit of electrical power is: ***(K.B)***

(A) Watt (B) Joule

(C) Ampere (D) Volt

4. One watt is equal to: ***(K.B+U.B)***

(A) Js (B) Js^{-1}

(C) J^2s (D) sJ^{-1}

5. How will you calculate power from current (I) and voltage (v)? ***(U.B)***

(A) Power =I/V (B) Power = VI

(C) Power = V^2 I (D) Power = VI^2

6. Which one of the following bulbs has least resistance? ***(U.B)***

(A) 100 watt (B) 200 watt

(C) 500 watt (D) 1000 watts

7. Electrical energy is measured in: ***(K.B)***

(A) Watt (B) Horse power

(C) Kilo watt (D) Kilowatt hour

8. Electrical energy is commonly consumed in very large quantity and hence a large unit of energy is To Find which is known as: ***(K.B)***

(A) Watt-hour (B) Milli-watt hour

(C) killowatt-hour (D) Megawatt - hour

9. One kilowatt-hour is equal to: ***(K.B)***

(A) 13.6 MJ (B) 13.6 kJ

(C) 3.6 kJ (D) 3.6 MJ

10. We can calculate the amount of electricity bill by the following formula: ***(U.B)***

(A) $\frac{\text{watt}\times\text{time}(\text{in hours})}{1000}\times$ cost of one unit (B) $\frac{\text{watt}\times 1000}{\text{time}(\text{in hours})}\times$ cost of one unit

(C) $\frac{1000\times\text{time}(\text{in hours})}{\text{Watt}}\times$ cost of one unit (D) $\frac{1000\times\text{watt}\times\text{time}(\text{in hours})}{\text{cost of one unit}}$

11. 1Kilowatt – hour is a unit of: ***(U.B)***

(A) Power (B) Work

(C) Energy (D) Current

EXAMPLE 14.7

The resistance of an elctric bulb is 500Ω. Find the power consumed by the bulb when a potential difference of 250 V is applied across its ends. ***(A.B+U.B)***

Solution:

Given data:

Resistance of electric bulb = R = 500Ω

Potential difference applied = V = 250 V

To Find:

Power consumed by the bulb = P = ?

Formula:

$$P = I^2R$$

Calculation:

To find the power consumed by the bulb, first we have to find the value of current. So by using formula, we have

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

Or $$I = \frac{250V}{500\Omega} \Rightarrow 0.5A$$

And $$\text{Power} = P = I^2R$$

Or $$P = (0.5A)^2 \times 500\Omega$$

$$P = 125W$$

Result:

Hence, the power consumed by the bulb will be 125 W.

EXAMPLE 14.8

Calculate the one month cost of using 50 W energy saver for 8 hours daily in your study room. Assume that the price of a unit is Rs. 12. ***(A.B+U.B)***

Solution:

Given data:

Power of energy saver $= P = 50W$

Usage time $= t = 8\,\text{hours} \times 30\,\text{days} = 240\,\text{Hrs}$

Price of a unit = Rs. 12

To Find:

One month cost = ?

Formula:

One month cost = No. Of units consumed × cost of one unit

Calculation:

To find one month cost first we have to find the no. Of units consumed, so by using formula, we have

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

Or $$= \frac{50 \times 240}{1000} = 12\,\text{units}$$

Therfore,

Total cost = No. of units consumed × cost of one unit

= 12 × 12 = Rs. 144

Result:

Hence, the total cost of using 50 W energy saver for 8 hours daily per month in study room will be Rs. 144.

14.12 DIRECT CURRENT AND ALTERNATING CURRENT

LONG QUESTIONS

Q.1 How electricity is distributed in our house? How electrical appliances are connected in houses? ***(K.B)***

Ans:

SUPPLY TO HOUSES

The electric power enters our house through three wires.

- Earthwire or Ground wire (E)
- Livewire (L)
- Neutral Wire (N)

Earthwire (E):

The earthwire is connected to a large metal plate buried deep in the ground near the house. This wire carries no electricity.

Neutral Wire (N):

The other wire is maintained at 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.

Livewire (L):

The third wire is at a high potential and is called livewire (L).

Potential Difference between Livewire and Neutral wire: **(GRW 2014)**

The electric power enters our houses through wires, the potential difference between the livewire 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 livewire current will start flowing to the ground while passing through his body which may prove fatal for the person.

Connection of Electrical Appliances:

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

Q.2 Explain the circuit of house wiring. ***(K.B+U.B)***

Ans:

HOUSE WIRING

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.

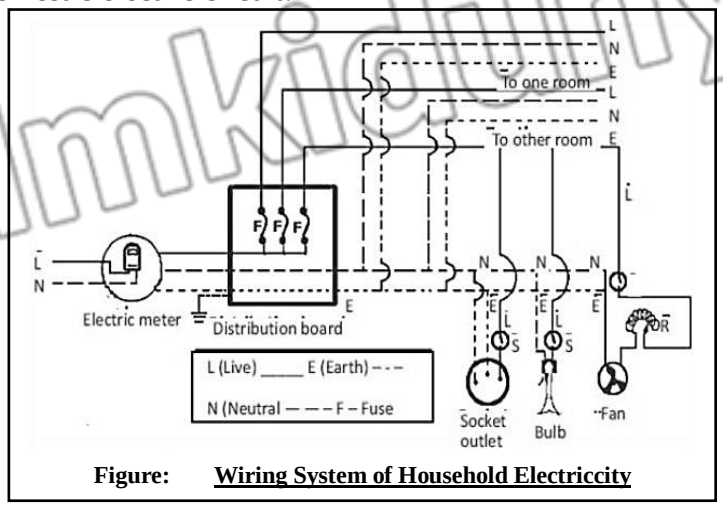


Figure: **Wiring System of Household Electriccity**

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

Connection of Appliances:

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.

14.12 SHORT QUESTIONS

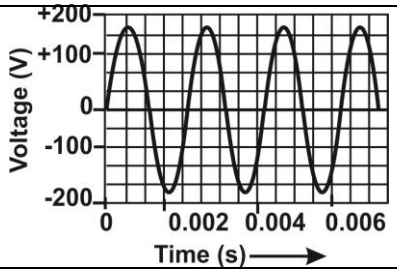
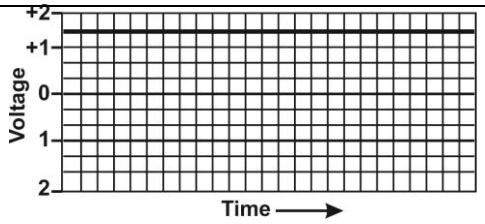
Q.1 What is difference between D.C. and A.C.? *(K.B)*

(GRW 2013, LHR 2013, 2016)(Review Question 14.9)

Ans:

DIFFERENTIATION

The differences between direct current and alternating current are as follows:

Alternating Current	Direct Current
Definition	
• A current that changes direction after equal intervals of time is called alternating current or a.c.	• The current derived from a cell or a battery is direct current (d.c.). **OR** • The current which does not change its direction after equal interval of time is called direct current.
Graph	
	
Polarity	
• It changes its polarity with equal intervals of time.	• It has fixed polarity.
Frequency	
• Its frequency is 50 Hz.	• Its frequency is zero.
Source	
• Its source is generator	• Its sources are battery and cell.

Q.2 What are live and neutral wires? *(K.B)* **(GRW 2013)**

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

- Neutral wire
- Livewire

NEUTRAL WIRE

Definition:

One wire is earthed at the power station, so it is at zero potential. This wire is called neutral wire.

Purpose:

This wire provide the return path of current.

Color Code:

It is black or blue in color.

LIVEWIRE

Definition:

The third wire is at a high potential and is called livewire.

Potential Difference between Live and Neutral Wire:

The potential difference between both wire is 220 V.

Color Code:

It is red or brown in color.

Q.3 What is earthwire? *(K.B)*

Ans: **EARTHWIRE**

Definition:

The earthwire is connected to a large metal plate buried deep in the ground near the house.

Color Code:

It is green or yellow in color.

Q.4 A bird can sit harmlessly on high tension wire. But it must not reach and grab neighboring wire. Do you know why? *(U.B+K.B)* **(Point to Ponder Pg. 102)**

Ans: **BIRD SITTING ON A HIGH TENSION WIRE**

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 can be fatal.

Figure: Bird Sitting on a High Tension Wire

Q.5 What is electrical grounding? *(K.B)* **(Electrical ground Pg. # 106)**

Ans: **ELECTRICAL GROUNDING**

Definition:

"If a charged object is connected with the Earth by a piece of metal, the charge is conducted away from the object to the Earth. This convenient method of removing the charge from an object is called grounding the object**"**.

Purpose of Grounding:

As a safety measure, the metal shells of electrical appliances are grounded through special wires that give electric charges in the shells paths to the Earth. The round post in the familiar three-prong electric plug is the ground connection.

Q.6 Incandescent light bulb fluctuates 50 times but we do not feel it why? *(K.B+U.B)*

(Do you know Pg. # 106)

Ans: **INCANDESCENT LIGHT BULB**

Although the light intensity from a 60 W incandescent light bulb appears to be constant, the current in the bulb fluctuates 50 times each second between -0.71 A and 0.71 A. The light appears to be steady because the fluctuations are too rapid for our eyes to perceive.

Q.7 What would be the effect of following currents on the body? *(K.B)*
(Effects of electric currents on the body Pg. # 108)

- **0.001 A**
- **0.005 A**
- **0.010 A**
- **0.015 A**
- **0.070 A**

Ans: **EFFECTS OF CURRENTS**
(Table for MCQs)

Effect of electric currents on the body	
0.001 A	Can be felt
0.005 A	Is painful
0.010 A	Causes involuntary muscle contractions (spasms)
0.015 A	Causes loss of muscle control
0.070 A	Goes through the heart; causes serious disruption; probably fatal if current lasts for more than 1 s.

Q.8 Draw the correct way of wiring of a three pin main plug. Also describe the importance of fuse in it. *(K.B)* **(For your information Pg. # 109)**

Ans: **CORRECT WAY OF WIRING**

This is the correct way of wiring of a three pin main plug. Put everything in proper place. Fuse is placed for safety purpose. In case of excess current, it will burn out and will break the circuit.

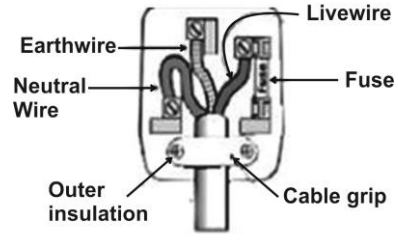


Figure: Correct Way of Wiring

14.12 MULTIPLE CHOICE QUESTIONS

1. The current which always flows in one direction is called: *(K.B)*
(A) Alternating current (B) Direct current
(C) Stationary current (D) Multi-directional

2. The current which changes its direction again and again is called: *(K.B)*
(A) Alternating current (B) Direct current
(C) Multi-directional current (D) Uni – directional current

3. The time interval after which the voltage repeats its value is known as: *(K.B)*
(A) Frequency (B) Wavelength
(C) Time period (D) None of these

4. The number of cycles completed by current in one second is called its: *(K.B)*
(A) Time period (B) Frequency
(C) Wavelength (D) Amplitude

5. The frequency of a.c used in our houses is: *(K.B)*
(A) 30 cycles / second (B) 50 cycles/ second
(C) 60 cycles/ second (D) 100cycles/ second

14.13 HAZARDS OF ELECTRICITY

LONG QUESTIONS

Q.1 Describe briefly the hazards of household electricity. ***(K.B)*** **(Review Question 14.12)**

Ans:

HAZARDS OF ELECTRICITY

Major dangers of electricity are electric shock and fire. Here we discuss some faults in electrical circuits that may cause electricity hazards.

Insulation Damage:

There are three reasons of insulation damage.

- Excess of current due to short circuit
- Friction
- Moisture

Excess of Current due to Short Circuit:

All electrical wires are well insulated with some plastic cover for the purpose of safety. But when 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. This results into a short circuit which can severely damage electrical devices or persons. A short circuit occurs when a circuit with a very low resistance is formed. The low resistance causes the current to be very large. When appliances are connected in parallel, each additional appliance placed in circuit reduces the equivalent resistance in the circuit and increases the current through the wires. This additional current might produce enough thermal energy to melt the wiring's insulation which causes a short circuit, or even starts a fire. Short circuit can also occur when the livewire and the neutral wires come in direct contact.

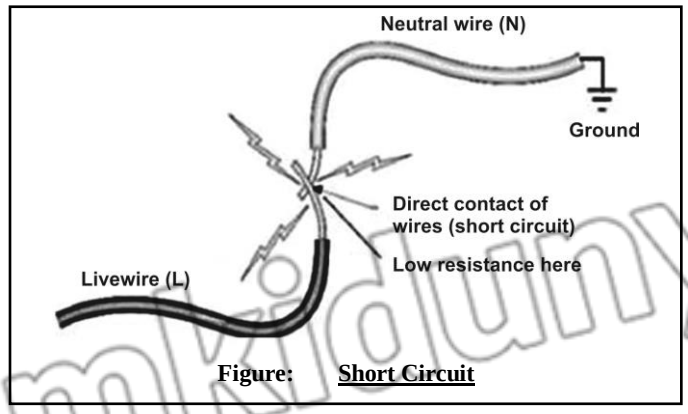


Figure: Short Circuit

Prevention:

- In order to avoid such situations, the wires carrying electricity should never be naked. Rather they should be covered with good insulator. Such an insulation covered wire is called cable.

Friction:

Constant friction may also remove the insulation from the wire

Prevention:

- In such a situation, it is advisable to use a cable with two layers of insulation.

Moisture:
Too much moisture also damages the insulation.

Damped Condition:
Dry human skin has a resistance of 100, 000 ohms or more! But under damp conditions (wet environment) resistance of human skin is reduced drastically to few hundred ohms.

Prevention:

- Never operate any electrical appliance with wet hands.
- Keep switches, plugs sockets and wires dry.

14.13 SHORT QUESTIONS

Q.1 How electricity is dangerous for us? ***(K.B)***

Ans: **DANGERS OF ELECTRICITY**

Our body is a good conductor of electricity through which current can easily pass. Therefore if a person holds livewire, 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.

Q.2 What is the resistance of dry and wet skin of a human body? ***(K.B+U.B)***

Ans: **RESISTANCE OF HUMAN BODY**

Dry human skin has a resistance of 100, 000 ohms or more! But under damp conditions (wet environment) resistance of human skin is reduced drastically to few hundred ohms.

Prevention:

- Never operate any electrical appliance with wet hands.
- Keep switches, plugs sockets and wires dry.

Q.3 Identify the following precautionary symbols. ***(K.B)*** **(Precautionary Symbols Pg. # 110)**

Ans: **PRECAUTIONARY SYMBOLS**

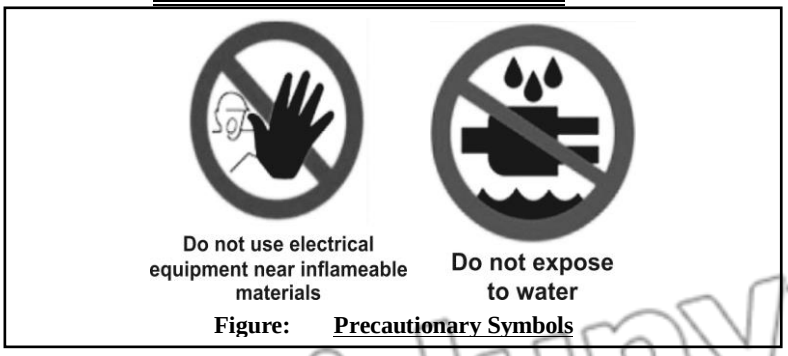


Figure: Precautionary Symbols

Q.4 Why flying kites near electricity lines is hazardous? ***(K.B)*** **(For your information Pg. # 110)**

Ans: **HAZARDOUS EFFECT OF FLYING KITES**

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

Figure: Hazardous Effect of Flying Kites

14.13 MULTIPLE CHOICE QUESTIONS

1. Resistance of dry skin is: ***(K.B)***

(A) 1000Ω (B) 10000Ω
(C) 100000Ω (D) None of these

2. Resistance of wet skin is: ***(K.B)***

(A) 1000Ω (B) 10000Ω
(C) 100000Ω (D) None of these

3. A short circuit occurs when a circuit is formed with: ***(K.B)***

(A) High resistance (B) Very low resistance
(C) Very high resistance (D) None of these

4. A short circuit occurs when a livewire comes in direct contact with: ***(K.B)***

(A) Neutral wire (B) Earthwire
(C) Livewire (D) None of these

14.14 SAFE USE OF ELECTRICITY IN HOMES

LONG QUESTIONS

Q.1 Write a note on fuse. ***(K.B+U.B)***

Ans: **FUSE**

Definition:

A fuse is a safety device that is connected in series with the livewire 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.

Figure: Different Types of Fuses

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 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: **(GRW 2015)**

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 will draw under normal conditions.

Example:

For a lightening circuit 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 4A which can be calculated using the formula P = VI

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

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

Q.2 What is the principle of circuit breaker? ***(K.B+A.B+U.B)*** **(GRW 2013)**

Ans:

CIRCUIT BREAKER

Definition:

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

Construction:

It consists of:

- Electromagnet
- Iron strip
- Spring

Working Principle:

The working principle of circuit breaker is electromagnetic induction.

Working:

When the normal current passes through the livewire the electromagnet is not strong enough to separate the contacts. If something goes wrong with the appliance and large current flows through the livewire, the electromagnet will attract the iron strip to separate the contacts and break the circuit.

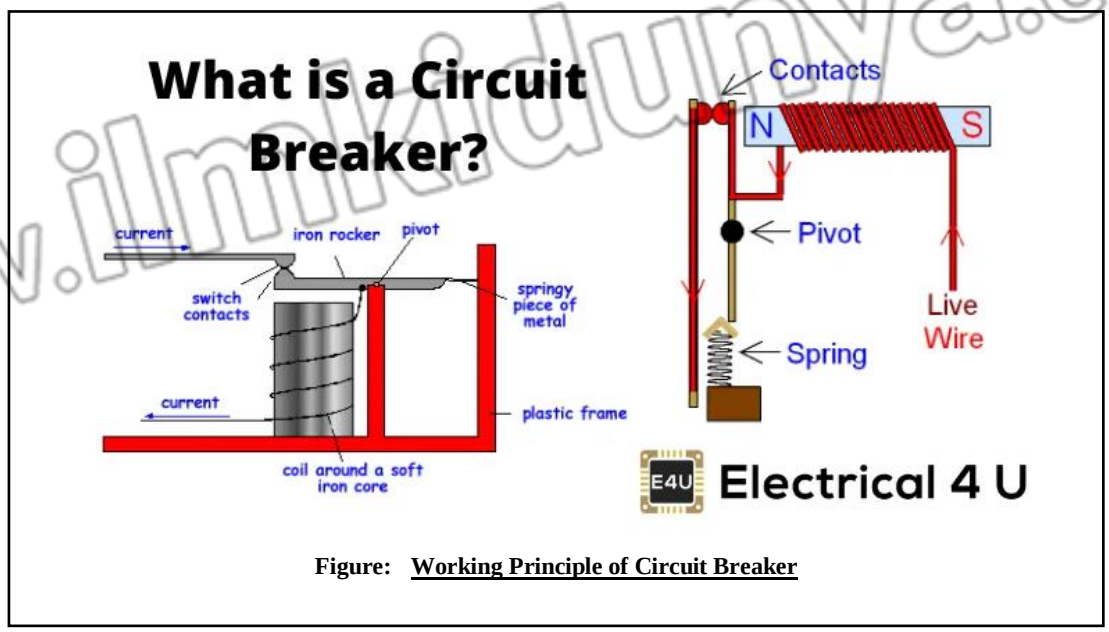


Figure: Working Principle of Circuit Breaker

The spring then keeps the contacts apart. After the fault is repaired, the contacts can then be pushed back together by pressing a button on the outside of the circuit breaker box.

Q.3 Explain the importance of Earthwire. ***(A.B)*** **(LHR 2016)**

Ans:

IMPORTANCE OF EARTHWIRE

Sometimes, even the fuse cannot capture the high currents coming from the livewire 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 earthwire provides a safe route for the current to flow through, if the livewire touches the casing.

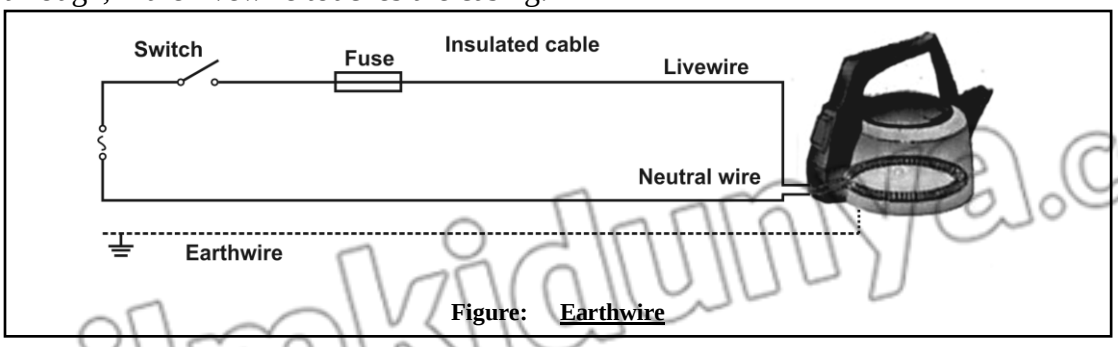


Figure: Earthwire

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

Working:

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

14.14 SHORT QUESTIONS

Q.1 Briefly describe the importance of safety devices. *(K.B)* **(GRW 2014)**

Ans:

IMPORTANCE OF SAFETY DEVICE

Definition;

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

Examples:

(i) Fuse
(ii) Circuit Breaker
(iii) Earthwire

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.2 What is cable? And how it should be used? *(K.B)*

Ans:

CABLE

Definition:

An insulated covered wire is known as cable.

Safe Use of 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.3 Define fuse and write down its principle. *(K.B)*

Ans:

FUSE

Definition:

A fuse is a safety device that is connected in series with the livewire in the circuit to protect the equipments when excess current flows.

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 and breaks the circuit.

Q.4 What do you know about Fuse rating? *(U.B)*

Ans:

FUSE RATING

We can determine the To Find 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 x 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.5 What is Circuit Breaker? Also write down its principle? *(K.B)*

Ans:

CIRCUIT BREAKER

Definition:

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

Working Principle:

The working principle of circuit breaker is electromagnetic induction.

Q.6 What is the function of Earthwire? ***(A.B+K.B)***

Ans: **FUNCTION OF EARTHWIRE**

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

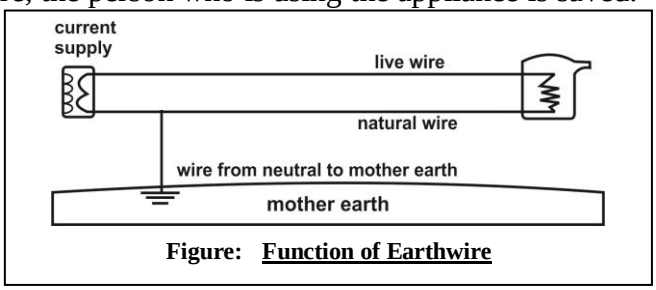


Figure: Function of Earthwire

Q.7 Identify circuit components from the symbols given below: ***(K.B)***

(Identifying circuit diagram Pg. # 111)

Ans: **IDENTFYING CIRCUIT COMPONENTS**

Circuit Components			
Wires crossed not joined	or	**Time-varying or AC supply**	v (t) or
Wires crossed at a junction		**Ammeter**	A
Variable resistor	or	**Voltmeter**	V
Fixed resistor	or	**Ohmmeter**	Ω
Diode	Or	**Thermister or temperature dependent resistor**	
Earth or ground		**Switch**	(open) or (closed)
Battery or DC supply	or	**Lamp / Bulb**	
Capacitor	or		

14.14 MULTIPLE CHOICE QUESTIONS

1. All electrical appliances are connected in parallel to each other between the main live and neutral wire to get: ***(K.B)***

(A) Same current (B) Same current and potential difference

(C) Different currents and potential differences (D) Same potential differences

2. Insulated covered wire is called: ***(K.B)***

(A) Extension (B) Cable

(C) Lead (D) None of these

3. The wire at certain potential is called: ***(K.B)***
(A) Livewire (B) Neutral wire
(C) Earthwire (D) Ground wire

4. The wire at zero potential is called: ***(K.B)***
(A) Livewire (B) Neutral wire
(C) Earthwire (D) Ground wire

5. The wire grounded in the earth is called: ***(K.B)***
(A) Livewire (B) Neutral wire
(C) Earthwire (D) Ground wire

6. A small wire connected in series with the livewire is called: ***(K.B)***
(A) Neutral wire (B) Earthwire
(C) Fuse (D) Circuit breaker

7. Safety device used in place of fuse is: ***(A.B)***
(A) Socket (B) Earthwire
(C) Plug (D) Circuit breaker

8. Circuit breaker works on the principle of: ***(K.B)***
(A) Electric current (B) Joule's law
(C) Electromagnetism (D) None of them

9. An additional wire used in devices having the metallic bodies is: ***(K.B)***
(A) Livewire (B) Neutral wire
(C) Earthwire (D) Ground wire

MCQ'S ANSWER KEY (TOPIC WISE)

14.1 ELECTRIC CURRENT

1	2	3	4	5	6	7	8	9	10	11	12
C	C	B	D	B	A	D	A	B	C	B	D
13	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	
C	C	B	A	B	B	B	A	C	A	C	

14.2 POTENTIAL DIFFERENCE

14.3 ELECTROMOTIVE FORCE (e.m.f)

1	2	3	4	5	6	7	8	9	10	11	12
B	C	A	B	B	A	D	D	D	B	B	C
13	**14**	**15**	**16**								
B	B	A	A								

14.4 OHM'S LAW

1	2	3	4	5	6	7	8	9	10
D	D	D	B	C	D	C	C	D	C

14.5 CHARACTERISTICS OF OHMIC AND NON OHMIC CONDUCTORS

1	2	3	4	5
A	A	B	B	B

14.6 SPECIFIC RESISTANCE (RESISTIVITY)

1	2	3	4	5	6	7	8	9
C	A	B	C	B	D	B	A	D

14.7 CONDUCTORS

14.8 INSULATORS

1	2	3	4	5
B	B	A	C	A

14.9 COMBINATION OF RESISTOR

1	2	3	4	5	6	7	8	9	10	11	12
B	A	C	D	A	C	A	B	C	C	C	B

13
B

14.10 ELECTRICAL ENERGY AND JOULE'S LAW

1	2	3	4
C	B	D	D

14.11 ELECTRIC POWER

1	2	3	4	5	6	7	8	9	10	11
B	C	A	B	B	A	D	C	D	A	C

14.12 DIRECT CURRENT AND ALTERNATING CURRENT

1	2	3	4	5
B	A	C	B	B

14.13 HAZARDS OF ELECTRICITY

1	2	3	4
C	A	B	A

14.14 SAFE USE OF ELECTRICITY IN HOMES

1	2	3	4	5	6	7	8	9
D	B	A	B	C	C	D	C	C

TEXT BOOK EXERCISE

MULTIPLE CHOICE QUESTIONS

Choose the correct answer form the following choices: ***(K.B)***

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.B+U.B)***

(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? ***(K.B)***

(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? ***(K.B)***

(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: ***(K.B)***

(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: ***(K.B)***

(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: ***(K.B)***

(a) remains unchanged (b) halves

(c) doubles (d) four times

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

(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: ***(U.B+A.B)***

(a) 2Ω (b) 4Ω

(c) 8Ω (d) 12 Ω

ANSWER KEY

i	ii	iii	iv	v	vi	vii	viii	ix
d	c	b	c	b	a	d	c	a

REVIEW QUESTIONS

14.1 Define and explain the term electric current. ***(K.B)***

Ans: (See Topic 14.1, Long Question-1)

14.2 What is the difference between electronic current and conventional current? ***(K.B)***

Ans:

DIFFERENTIATION

The differences between electronic current and conventional current are as follows:

Electronic Current	Conventional Current
• The rate of flow of electrons through any cross-sectional area is called electronic current • It flows from negative to positive terminal of the battery	• The rate of flow of positive charges through any cross-sectional area is called conventional current. • It flows from positive to negative terminal of the battery.

14.3 What do we mean by the term e.m.f? Is it really a force? Explain. ***(K.B)***

Ans: (See Topic 14.2 & 14.3, Long Question-2)

14.4 How can we differentiate between e.m.f and potential difference? ***(K.B)***

Ans: (See Topic 14.2 & 14.3, Short Question-5)

14.5 Explain Ohm's law. What are its limitations? ***(K.B+A.B)***

Ans: (See Topic 14.4, Long Question-1)

14.6 Define resistance and its units. ***(K.B+A.B)***

Ans: (See Topic 14.4, Short Question-2)

14.7 What is the difference between conductors and insulators? ***(K.B)***

Ans: (See Topic 14.7, Long Question-1)

14.8 Explain the energy dissipation in a resistance. What is Joule's law? ***(K.B+U.B+A.B)***

Ans:

ENERGY DISSIPATION

When electric charge move from higher potential to lower potential it delivered electric current, during this process some of the energy is utilized attain the internal resistance of a conductor. In this process some of the energy will lost. This is called, powered dissipation.

(Joule's law is given on Page # 240)

14.9 What is difference between D.C. and A.C? *(K.B)*

Ans: (See Topic 14.12, Short Question-1)

14.10 Discuss the main features of parallel combination of resistors. *(K.B)*

Ans: (See Topic 14.9, Long Question-2)

14.11 Determine the equivalent resistance of series combination of resistors. *(U.B)*

Ans: (See Topic 14.9, Long Question-1)

14.12 Describe briefly the hazards of household electricity? *(K.B)*

Ans: (See Topic 14.13, Long Question-1)

14.13 Describe four safety measures that should be taken in connection with the household circuit. *(K.B)*

Ans:

SAFETY MEASURES

Following safety measures should be taken in connection with the house hold circuits.

(i) Use fuse and circuit breakers in an electric circuit as safety devices. They prevent circuit overloads that can occur when too many appliances are turned ON at the same time or when a short circuit occurs in one appliance.

(ii) Separate connection is taken from livewire is from each appliance.

(iii) The terminal of the appliance is connected to the livewire through a separate fuse or a circuit breaker and a switch.

(iv) Earthing protects the user from electric shock by connecting the metal casing of the appliance to earth. Many electric appliances have metal cases included cookers, washing machines and refrigerator. The earthwire provides a save route for the current to flow through, if the livewire touches the casing.

14.14 Design a circuit diagram for a study room that needs the following equipment in parallel. *(K.B+U.B)*

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

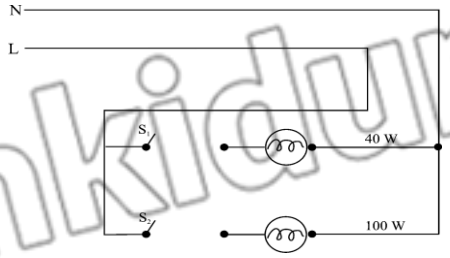
(b) One reading lamp fitted with a 40 W bulb which can be switched ON and OFF from two points.

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

Ans:

CIRCUIT DIAGRAM

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



(c)

ADVANTAGES OF PARALLEL COMBINATION

Parallel circuits have two big advantages over series circuits.

- Each device in the circuit receives the full battery voltage.
- Each device in the circuit may be turned off independently without stopping the current flowing to the other devices in the circuit. This principle is used in household wiring.
-

CONCEPTUAL QUESTIONS *(A.B)*

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

Ans: **TRANSFER OF CHARGE**

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: (See Topic 14.2 & 14.3, Short Question-6)

14.3 Can current flow in a circuit without potential difference?

Ans: **FLOW OF CURRENTN& POTENTIAL DIFFERENCE**

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: **FLOW OF CHARGE BETWEEN TWO POINTS**

If object is a conductor and its two points are at different electric potentials, the charge will necessarily flow between these points. If objects is an insulator and its two points are at different electric potentials, the charge will not flow between these points.

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

Ans: **CONNECTION OF AMMETER IN A CIRCUIT**

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: **CONNECTION OF VOLTMETER IN A CIRCUIT**

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: **CONVERSION OF JOULES INTO WATT-HOUR**

As we know,

$$1 \text{ watt} \times 3600\text{s} = 1 \text{ watt-hour}$$

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

Result:

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: **HEADLAMPS IN SERIES**

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: **FLASH LIGHT**

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: **IMPRACTICABLE CONNECTION**

When appliances are connected in series, total resistance of circuit increases. This decreases the current and hence the power through each appliance. Also if one appliance stops working due to some fault, other will also not run.

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

Ans: **FUNCTION OF FUSE**

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.

14.12 Why the house wiring is always do in parallel combination?

Ans: For domestic circuits parallel arrangement is always used because. In parallel circuit, each electrical appliance has own switch due to which it can be turn off or on independently, without effecting other appliances. In parallel circuits, each electrical appliance gets same voltage as that of the power supply line. And in parallel combination the combine resistance of circuit is very very low.

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

NUMERICAL PROBLMES *(U.B+A.B)*

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

Solution:

Given:

Current=I=3mA

$I=3\times10^{-3}A$

Time=t=1min

t=60s

To Find:

Charge=Q=?

Formula:

$Q=I\times t$

Calculations:

Putting the values from given data into the formula

$Q=3\times10^{-3}A\times60s$

$Q=180\times10^{-3}C$

Result:

Hence, the charge flowing through the wire will be 180×10^{-3}C.

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 you receive from the same battery?

Solution:

Given:

Resistance of dry body=R_1=100,000Ω

Resistance of wet body=R_2=1000Ω

Voltage=V=12V

To Find:

Current through dry body=I_1=?

Current through wet body=I_2=?

Formula:

I=V/R

Calculations:

Current through dry body:

Putting the values from given data into the formula

I=12V/100,000 Ω

$I=1.2\times10^{-4}A$

Current through wet body:

Putting the values from given data into the formula

I=12V/1000 Ω

$I=1.2\times10^{-2}A$

Result:

Hence, current through dry body is 1.2×10^{-4}A and through wet body will be 1.2×10^{-2}A.

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:

Resistance of a conductor wire=R=10M Ω

$R=10\times10^{6}$ Ω

Voltage=V=100V

To Find:

Current=I=?

Formula:

I=V/R

Calculations:

Putting the values from given data into the formula

$I=100V/10\times10^{6}$ Ω

$I=10^{2-1-6}A$

$I=10^{-5}A$

$I=10^{-2}\times10^{-3}A$

I=0.01mA

Result:

Hence, current through the conductor wire will be 0.01mA.

14.4 By applying a potential difference of 10 V across a conductor a current of1.5A passes through it. How much energy would be obtained from the current in 2 minutes?

Solution

Given:

Potential difference=ΔV=10V

Current=I=1.5A

Time=t=2min

t=2×60=120s

To Find:

Energy=E=W=?

Formula:

E=VIt

Calculations:

Putting the values from given data into the formula

E=10V×1.5A×120s

E=1800J

Result:

Hence, 1800J energy would be

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

First resistance=R_1=2kΩ

$R_1=2\times10^3$ Ω

Second resistance=R_2=8k Ω

$R_2=8\times10^3$ Ω

Potential difference=ΔV=10V

To Find:

Equivalent resistance=R_e=?

Current through first resistance $R_1=I_1$=?

Current through second resistance $R_2=I_2$=?

Potential difference across $R_1=V_1$=?

Potential difference across $R_2=V_2$=?

Formula:

Since resistors are connected in series combination therefore

$R_e=R_1+R_2$……(1)

And,

$I_1=I_2=I=V/R_e$……(2)

$V_1=IR_1$……..(3)

$V_2=IR_2$……..(3)

Calculations:

Putting the values from given data into the formula (1)

R_e=2kΩ+8kΩ

R_e=10kΩ

Putting the values from given data into the formula (2)

$I_1=I_2=I=10V/10\times10^3\Omega$

$I_1=I_2=I=1\times10^{-3}A$

$I_1=I_2=I$=1mA

Putting the values from given data into the formula (3)

$V_1=1\times10^{-3}A\times2\times10^3$ Ω

V_1=2V

Putting the values from given data into the formula (4)

$V_2=1\times10^{-3}A\times8\times10^3$ Ω

V_2=8V

Result:

Hence,
Equivalent resistance=R_e=10kΩ
Current through first resistance $R_1=I_1$=1mA
Current through second resistance $R_2=I_2$=1mA
Potential difference across $R_1=V_1$=2V
Potential difference across $R_2=V_2$=8V

14.6 Two resistances 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:

First resistance=R_1=6kΩ

$R_1=6\times10^3$ Ω

Second resistance=R_2=12k Ω

$R_2=12\times10^3$ Ω

Potential difference=ΔV=6V

To Find:

Equivalent resistance=R_e=?

Current through first resistance $R_1=I_1$=?

Current through second resistance $R_2=I_2$=?

Potential difference across $R_1=V_1$=?

Potential difference across $R_2=V_2$=?

Formula:

Since resistors are connected in parallel combination therefore

$1/R_e=1/R_1+1/R_2$…….(1)

And,

$V_1=V_2=V$…….(2)

$I_1=V/R_1$……..(3)

$I_2=V/R_2$……..(4)

Calculations:

Putting the values from given data into the formula (1)

$1/R_e=1/6k\Omega+1/12k\Omega$

$1/R_e=(2+1)/12k\Omega$

$1/R_e=3/12k\Omega$

$1/R_e=1/4k\Omega$

$R_e=4k\Omega$

Putting the values from given data into the formula (2)

$V_1=V_2=6V$

Putting the values from given data into the formula (3)

$I_1=6V/(6\times10^3\ \Omega)$

$I_1=1\times10^{-3}$ A

$I_1=1mA$

Putting the values from given data into the formula (4)

$I_2=6V/(12\times10^3\ \Omega)$

$I_2=0.5mA$

Result:

Hence,

Equivalent resistance=R_e=4kΩ

Current through first resistance $R_1=I_1$=1mA

Current through second resistance $R_2=I_2$=0.5mA

Potential difference across $R_1=V_1$=6V

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:

Voltage=V=220V
Power=P=100W
Time=t=5 hours
No. of days=30 days

To Find:

Resistance of the bulb=R=?
Energy in kWh=E=?

Formula:

$P=V^2/R$……(1)
Energy (kWh)=Power(watt)×time(hours)×days/1000……(2)

Calculations:

Putting the values from given data into the formula (1)

$100=220^2/R$

$R=220^2/100$

R=484Ω

Putting the values from given data into the formula (2)

Energy=100×5×30/1000

Energy=15kWh

Result:

Hence, resistance of the bulb is 484Ω and energy consumed in 30 days will be 15kWh.

14.8 An incandescent light bulb with an operating resistance of 95 Ω is labelled "150 W." Is this bulb designed for use in a 120V circuit or a 220V circuit?

Solution:

Given:

Resistance of the bulb=R=95 Ω

Power of the bulb=P=150W

To Find:

Is it designed for 120V or 220V=?

Formula:

$P=V^2/R$

Or

$V^2=P\times R$

Calculations:

Putting the values from given data into the formula

$V^2=150\times 95$

$V^2=1450$

Taking square root on both sides

$V=120V$

Result:

Hence, the bulb is designed for 120V.

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 75 W each of which run 10 hours daily.

(C) One T.V. of 100 W which is used for 5 hours daily.

(D) One electric iron of 1000 W which is used for 2 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:

Power of each bulb=60W

No. of bulbs=10

Total power of bulbs=$P_1=10\times 60$

$P_1=600W$

Time for bulbs= $t_1=5$ hours daily

Power of each fan=75W

No. of fans=4

Total power of bulbs=$P_2=4\times 75$

P_2=300W

Time for fans=t_2=10 hours daily

Power of each T.V. =100W

No. of T.V.=1

Total power of T.V.=P_3=1×100

P_3=100W

Time for T.V.=t_3=5 hours daily

Power of each electric iron =1000W

No. of electric iron =1

Total power of electric iron =P_4=1×1000

P_4=1000W

Time for electric iron =t_4=2 hours daily

Cost of one unit of electricity=Rs.4 per unit

No. of days=30 days

To Find:

Expenditure of electricity=?

Formula:

Units (kWh)= Power(watts)×time(hours)×days/1000……..(1)

Cost of electricity=units ×cost per unit……..(2)

Calculations:

Putting the values from given data into the formula (1)
Units consumed by bulbs= 600×5×30/1000
Units consumed by bulbs=90 units
Units consumed by fans= 300×10×30/1000
Units consumed by fans=90 units
Units consumed by T.V.= 100×5×30/1000
Units consumed by T.V.=15 units
Units consumed by electric iron= 1000×2×30/1000
Units consumed by electric iron=60 units
Total units consumed in 30 days= 90+90+15+60
Total units consumed in 30 days=255 units
Putting the values from given data into the formula (2)
Cost of electricity=255 ×4
Cost of electricity=Rs.1020

Result:

Hence, cost of electricity will be Rs.1020.

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

(B) The resistance of each appliance when in use.

Solution:

Given:

Power of a lamp=P_1=100W

Power of a water heater=P_2=4kW

P_2=4000W

Voltage=V=250V

To Find:

Current through a lamp=I_1=?

Current through a water heater=I_2=?

Resistance across a lamp=R_1=?

Resistance across a water heater=R_2=?

Formula:

I=P/V……(1)

R=V/I……(2)

Calculations:

For lamp:

Putting the values from given data into the formula (1) and (2) respectively

I=100/250

I=0.4A

And,

R=250/0.4

R=625 Ω

For water heater:

Putting the values from given data into the formula (1) and (2) respectively

I=4000/250

I=16A

And,

R=250/16

R=15.625 Ω

Result:

Hence, cost of electricity will be Rs.1020.

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. A current of 0.5 A passes through the resistor. Calculate

(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:

Resistance=R=5.6 Ω

Voltage=V=3.0V

Current=I=0.5A

To Find:

Power dissipated in the resistor=P_1=?

Power produced by the battery=P_2=?

Formula:

$P_1=I^2R$……(1)

$P_2=VI$…….(2)

Calculations:

Putting the values from given data into the formula (1)

$P_1=0.5^2\times5.6$

$P_1=1.4W$

Putting the values from given data into the formula (2)

$P_2=3\times0.5$

$P_2=1.5$ W

Result:

Hence, total power produced by the battery will be 1.5W while power dissipation by the resistor is 1.4W. There is a difference of 0.1W because some power will be lost by the internal resistance of the battery.

SELF TEST

Time: 40 min. **Marks: 25**

Q.1 Four possible answers (A), (B), (C) & (D) to each question are given, mark the correct answer. (6×1=6)

1. What is the power rating of a lamp connected to 12 V source when it carries 2.5 A?

(A) 60 W (B) 30 W
(C) 14.5 W (D) None of these

2. The resistance of dry human skin is (Ω):

(A) 1000 (B) 10000
(C) 100000 (D) None of these

3. The color code of neutral wire is:

(A) Black (B) Red
(C) Blue (D) Both (B) and (D)

4. Specific resistance of copper is ($\times 10^{-8}$ Ω m) :

(A) 1.69 (B) 1.54
(C) 2.73 (D) None of these

5. The combined resistance of two identical resistors, connected in series is 16 Ω. Their combined resistance in a parallel arrangement will be:

(A) 2 Ω (B) 4 Ω
(C) 8 Ω (D) None of these

6. Example of ohmic conductors is:

(A) Thermistor (B) Plastic
(C) Wood (D) None of these

Q.2 Give short answers to following questions. (5×2=10)

i. Why in conductors charge is transferred by free electrons, rather than by positive charges?
ii. What do you mean by conventional current?
iii. Define unit of resistance.
iv. What are the advantages of parallel combination?
v. Differentiate between A.C and D.C.

Q.3 Answer the following questions in detail. (4+5=9)

a) Define and explain the term specific resistance. Discuss different factors which affect the resistance of conductors.

b) An incandescent light bulb with an operating resistance of 95 Ω is labelled "150 W". Is the bulb designed for use in a 120 V or 220 V circuit?

Note:

Parents or guardians can conduct this test in their supervision in order to check the skill of students.