CHAPTER 12- ELECTRICITY

INTRODUCTION Electricity is a controllable and convenient form of energy used for operating various devices at homes, hospitals and schools. An electrically charged particle (electron) is the basic carrier of electricity.

ELECTRIC CHARGE There are two types of electric charges *positive* and *negative* (commonly carried by protons and electrons respectively). Like charges repel each other and unlike charges attract each other. An object with an absence of net charge is referred to as neutral. Charge is always conserved and quantized.

- Denoted by 'q'
- Formula q=n.e where n=number of electrons and e= electronic charge=$1.6X10^{-19}$
- S I unit- Coulomb (C)

ELECTRIC CIRCUIT An **electrical circuit** is a continuous and closed path in which electrons from a voltage or current source flow. If the circuit is broken, current ceases to flow. A key or a switch is employed to make a conducting link between a cell and a device.

ELECTRIC CURRENT An **electric current** is the rate of flow of electric charge.

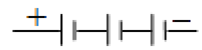
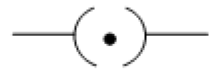
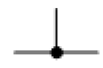
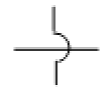
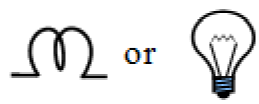
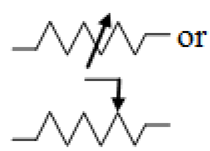
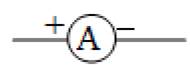
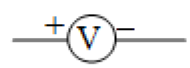
- Denoted by 'I'
- Formula I= q/t where q= electric charge and t=time for which switch is on
- S I unit- Ampere (A)
- Measured by ammeter connected in series in the circuit.

ELECTRIC POTENTIAL The **electric potential of a point** is the amount of work needed to move a unit of charge from a infinity(0V) to that specific point.

POTENTIAL DIFFERENCE Charges in a circuit do not move on their own. A cell or a battery is employed to maintain a potential difference between the two points in a circuit. Potential difference between two points in a circuit is the difference of their electric potentials.

- Denoted by 'V'
- Formula V=W/q where W=Work done and q=charge
- SI unit-Volt(V)
- Measured by voltmeter connected in parallel to the circuit.

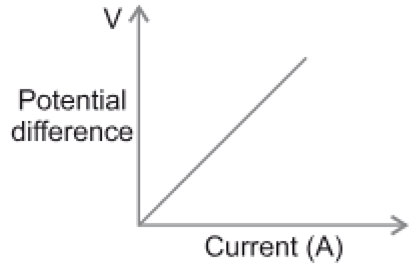
<u>CIRCUIT DIAGRAM</u> A **circuit diagram** is a graphical representation of an electrical **circuit** showing the components and interconnections of the **circuit** using standardized symbolic representations.

S.N	Components	Symbols
1.	Electric cell	
2.	Battery	
3.	Plug key (switch open)	
4.	Plug key (switch closed)	
5.	A wire joint	
6.	Wires crossing without joining	
7.	Electric bulb	
8.	A resistor of resistance R	
9.	Variable resistance or rheostat	
10.	Ammeter	
11.	Voltmeter	
12.	Fuse	

<u>OHM'S LAW</u> Ohm's law states that the current through a conductor between two points is directly proportional to the voltage across the two points, provided the physical conditions like temperature, pressure etc. are kept constant.

Mathematically, $V \alpha I$

Introducing the constant of proportionality, the resistance(R) we arrive at the usual mathematical equation, $V=IR$



The slope of V-I curve determines resistance graphically.

RESISTANCE It is the obstruction offered by the immobile positive ions in the conductor to the flow of current through it.

- Denoted by 'R'
- Formula R=V/I
- SI unit- Ohm(Ω)

FACTORS ON WHICH RESISTANCE DEPENDS There are 4 parameters for dependence of resistance

1. *Nature of material*- Insulators offer high resistance whereas conductors offer low resistance values.
2. *Temperature*- The resistance of conductors and insulators increases linearly with increase in temperature whereas it decreases with an increase in temperature for semiconductors.
3. *Length of the conductor*- The resistance of a conductor increases linearly with increase in its length, i.e., Rα l
4. *Area of cross section of conductor*- The resistance of a conductor decreases linearly with increase in its area of cross section, i.e., Rα (1/A)

RESISTIVITY **Electrical resistivity** or **specific electrical resistance** is a fundamental property of a material that quantifies how strongly it resists or conducts electric current. A low resistivity indicates a material that readily allows electric current. Numerically, it is equal to the resistance of a conductor of unit length and cross section.

- Denoted by 'ρ' rho.
- Formula ρ =RA/l
- SI unit- Ohm-meter (Ω-m)

Q1. What happens to resistance when length of conductor is doubled without affecting the thickness of conductor?

Q2. A wire of length 3 m and area of cross-section 1.7×10^{-6} m^2 has a resistance 3×10^{-2} ohm.

a. What is the formula for resistivity of the wire and what is the unit of it
b. Calculate the resistivity of the wire

Q3. What is an ammeter?
Q4. Calculate the number of electrons constituting one coulomb of charge.

Q5. What is meant by electric resistance of a conductor?
Q6. Define resistance of a conductor.
Q7. Write SI unit of resistivity.
Q8. How does the resistivity of alloys compare with those of pure metals form which they may have formed?

Q9. When a 15 V battery is connected across an unknown resistor, 2.5 mA current flows in the circuit. Find the resistance of the resistor.

Q10.(a) What material is used in making the filament of an electric bulb?
(b) Name the characteristics which make it suitable for this.

Q11. State Ohm's law. How can it be verified experimentally? Does it hold good in all conditions? Comment.

Q12. What is the resistance of 12 m wire having radius 2×10^{-4} m and resistivity 3.14×10^{-8} Ω-m.

RESISTANCE OF A SYSTEM

1. *Series connection*- equal current, different potential difference across each resistor. In a series connection, the total resistance of a circuit is determined by adding the resistance of each individual resistors.
   $R_{eq} = R_1 + R_2 + R_3 \ldots\ldots\ldots\ldots R_n$.
2. *Parallel connection*- equal potential difference, different current flowing through each resistor. In a parallel connection, the reciprocal of total resistance of a circuit is determined by adding the reciprocal of the resistance of each individual resistor.
   $1/ R_{eq} = 1/ R_1 + 1/ R_2 + 1/ R_3 \ldots\ldots\ldots\ldots 1/ R_n$.

Q1. Find the lowest and highest resistance which can be obtained by combining four resistors of resistance 4 ohm,8 ohm ,12 ohm and 24 ohm.

Q2. How do we connect ammeter and voltmeter in an electric circuit? Draw a circuit diagram to justify your answer. What is likely to happen if the positions of these instruments are interchanged? Give reason.

Q3. A student has a resistance wire of 1 ohm. If the length of this wire is 50 cm, to what length he should stretch it uniformly so as to obtain a wire of 4 Ω resistance? Justify your answer.

Q4. The resistance per meter length of a wire is 10 Ω. If the resistivity of the material of the wire is 50×10^{-8} ohm meters, find the area of cross – section of the wire.
Q5.*The resistance of a wire of 0.01 cm radius is 10 Ω. If the resistivity of the material of the wire is 50×10^{-8} ohm meters, find the length of the wire.*

HEATING EFFECT OF ELECTRIC CURRENT Whenever current is passed through a conductor, it heats up. This effect is utilized in applications as electric oven, iron, geyser, microwave etc.

According to Joule's law of heating, heat

$H \propto I^2$, square of current flowing through the conductor

$H \propto R$, Resistance offered by the conductor

$H \alpha t$, time for which the current is passed through the conductor

Combining these three,

$H = I^2Rt$

ELECTRICAL ENERGY Because of the existence of resistance to the flow of current work has to be done to maintain the flow of current. This work done is stored as energy.

$W=qV$

$I= q/t$. This implies $q= It$

So, $W= ItV$

Since $V=IR$

$W= VIt = V^2t/R = I^2Rt$

Commercial unit of electrical energy is kilowatt-hour (kWh)

$1 \text{ kWh} = 3.6 \times 10^6 \text{ J}$

ELECTRIC POWER The rate at which electrical energy is consumed is called electric power.

Power = Work done / time

$P = VI = V^2/R = I^2R$

Q1. State the factors on which the heat produced in a current carrying conductor depends. Give one practical application of this effect.
Q2. *Write the relation between electric power (W) of a device with potential difference (Volt) across it and current (I) flowing through it.*

Q3. What is relation between KWh and Joule?

Q4. Why is Tungsten used almost exclusively for filament of electric lamps?

Q5. Why does the cord of an electric heater not glow while heating element does?

Q6. Why do we use copper wire as connecting wires in the circuit?

Q7. An electric iron consumer's energy at a rate of 840 W when heating is at the maximum rate and 360 W when the heating is at the minimum,the voltage is 220 V. What are the current and the resistance in each case ?

Q8.a. What does an electric circuit mean?
b. Name a device that helps to maintain a potential difference across a conductor in a circuit.
c. When do we say that the potential difference across a conductor is 1 volt?
d.Calculate the amount of work done in shifting a charge of 2 coulombs from a point A to B having potentials 10 V and 5V respectively.

Q9. List two distinguishing features between the resistance and resistivity of a conductor. A wire is stretched so that its length becomes 6/5 times of its original length. If its original resistance is 25 Ω find its new resistance. Give justification for your answer in each case.

Q10. Obtain the expression for the heat developed in a resistor by the passage of electric current through it. 220 J of heat is produced each second in a 8 ohm resistor. Find the potential difference across the resistor.