BAL BHARATI PUBLIC SCHOOL, PITAMPURA, DELHI – 110034

SUBJECT:-PHYSICS CLASS X

TOPIC:- ELECTRICITY

Week: 5th October to 9th October

No of blocks: 1 or 2

GUIDELINES FOR STUDENTS:

Dear students,

- There is only one assignment detailed as follows:
  - Assignment 7: Heating effects of current
- Solve the assignment in a separate notebook you have made for Physics
- Suitable Video links have been provided for better understanding of the concept.
- Do read NCERT too for better understanding of these concepts

SUBTOPICS: (a) Heating effect of current (b) Electric power

Instructional aids /Resources:

NCERT LINK FOR THE CHAPTER:

https://ncert.nic.in/textbook.php?jesc1=12-16 (Page no. 216-220)

YouTube Links:

https://www.youtube.com/watch?v=yfMgSUyiBkM
https://www.youtube.com/watch?v=BLIYsRwKrkE

Learning Outcomes:

Each learner will be able to:

1. State Joule,s law of heating
2. Derive the expression for the Joule's law of heating
3. Explain the cause of heating effect of current
4. Solve numerical problems based on these concepts.
5. Analyse the reason to connect the fuse wire in various circuits.
6. Reason for the choice of various materials as the preferable filament of that appliance.

Lesson Development:

Previous knowledge:

- The chemical reaction within the cell generates the potential difference between its two terminals that sets the electrons in motion to flow the current through a resistor or a system of resistors connected to the battery.
- To maintain the current, the source has to keep expending its energy.

Where does this energy go?

A part of the source energy in maintaining the current may be consumed into useful work (like in rotating the blades of an electric fan).
Rest of the source energy may be expended in heat to raise the temperature of gadget.

For example, an electric fan becomes warm if used continuously for longer time etc.

On the other hand, if the electric circuit is purely resistive, that is, a configuration of resistors only connected to a battery; the source energy continually gets dissipated entirely in the form of heat. This is known as the **heating effect of electric current**.

This effect is utilised in devices such as electric heater, electric iron etc.

Consider a current I flowing through a resistor of resistance R.
Let the potential difference across it be V .
Let t be the time during which a charge Q flows across.

The work done in moving the charge Q through a potential difference V is VQ.
W=VQ

Hence the power input to the circuit by the source is
P =W/t =VI

Or the energy supplied to the circuit by the source in time t is
E= P × t = VIt.

What happens to this energy expended by the source?

This energy gets dissipated in the resistor as heat. Thus for a steady current I, the amount of heat H produced in time t is

H = VIt

Applying Ohm's law $H = I^2 Rt$

This is known as Joule's law of heating.

The law implies that heat produced in a resistor is

(i) directly proportional to the square of current for a given resistance,
(ii) directly proportional to resistance for a given current,

and

(iii) directly proportional to the time for which the current flows through the resistor.

Practice questions:

A. Compute the heat generated while transferring 96000 coulomb of charge in one hour through a potential difference of 50 V.
Solution:
H= VQ = 50x 96000 = 4800000 J

B. An electric iron of resistance 20 Ω takes a current of 5 A.
Calculate the heat developed in 30 s.

$H= I^2Rt = 25x\ 20x\ 30 = 15000J$

<u>Practical Applications of Heating Effect of Electric Current :</u>

- The electric laundry iron, electric toaster, electric oven, electric kettle and electric heater are some of the familiar devices based on Joule's heating.
- The electric heating is also used to produce light, as in an **electric bulb**. Here, the filament
  - must retain as much of the heat generated as is possible, so that it gets very hot and emits light.
  - It must not melt at such high temperature. A strong metal with high melting point such as tungsten (melting point 3380°C) is used for making bulb filaments.

- The filament should be thermally isolated as much as possible, using insulating support, etc. The bulbs are usually filled with chemically inactive nitrogen and argon gases to prolong the life of filament.

Most of the power consumed by the filament appears as heat, but a small part of it is in the form of light radiated.

- Another common application of Joule's heating is **the fuse used in electric circuits.**

Function:It protects circuits and appliances by stopping the flow of any unduly high electric current.

HOW IT WORKS:

The fuse is placed **in series** with the device.
It consists of a piece of wire made of **a metal or an alloy of appropriate melting point**, for example aluminium, copper, iron, lead etc
If a current larger than the specified value flows through the circuit, the temperature of the fuse wire increases. This melts the fuse wire and breaks the circuit. The fuse wire is usually encased in a cartridge of porcelain or similar material with metal ends.

The fuses used for domestic purposes are rated as 1 A, 2 A, 3 A, 5 A, 10 A, etc. e.g. For an electric iron which consumes 1 kW electric power when operated at 220 V, a current of (1000/220) A, that is, 4.54 A will flow in the circuit. In this case, a 5 A fuse must be used.

ELECTRIC POWER

It is the rate at which electric energy is dissipated or consumed in an electric circuit.

$P = VI$ Or $P = I^2R = V^2/R$
The SI unit of electric power is watt (W).
It is the power consumed by a device that carries 1 A of current when operated at a potential difference of 1 V.
Thus, 1 W = 1 volt × 1 ampere = 1 V A
Other units are 1kilowatt =1000 watts.
$1MW = 10^6 W$

Commercial Unit of electrical energy: kW h (unit)

Electrical energy = power x time.
1 kW h = 1000 watt × 3600 second = 3.6 × 106 watt second = 3.6 × 106 joule

Practice Questions:

C.An electric motor takes 5 A from a 220 V line. Determine the power of the motor and the energy consumed in 2 h.

P= VI =220x5 =1100 W =1.1kW
E= Pxt =1.1x2 =2.2kW

D.Several electric bulbs designed to be used on a 220 V electric supply line, are rated 10 W. How many lamps can be connected in parallel with each other across the two wires of 220 V line if the maximum allowable current is 5 A?

Current through one bulb= I=P/V = 10/220= 1/22 A

Current through n bulbs = n/22 A

n/22=5 so n=110bulbs

Now solve the following assignment:

Assignment 7:

1.An electric iron consumes 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?

2. 100 J of heat is produced each second in a 4 Ω resistance. Find the potential difference across the resistor.

NCERT back exercise: questions 13,14,15,16,17,18

x----------x----------x