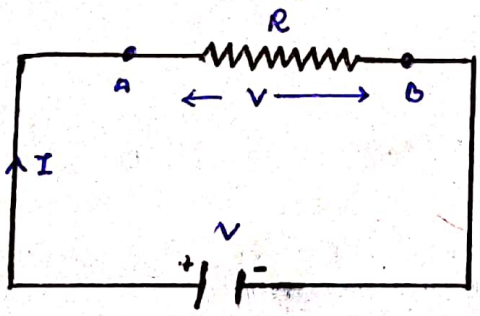
Sub:- Applied Physics

Class - MPE, EEE, ELEX (1st year)

Topic:- Heating effect of current, Electric Power, Electrical Energy & its units.

[1] **Heating effect of current : Joule's law:-** it is phenomenon in which heat is produced when current is passed through a wire or conductor. it is due to transfer of energy from electron (constituting the current) to the ions & atoms in the conductor. As a result the ions & atoms constituting the resistor vibrate more vigorously & its gets heated.

Let us consider following circuit diagram —



Let a current I is flows in the circuit for time t. then the charge flowing through the conductor is

$$\Rightarrow Q = It \quad \text{---------- (1)}$$

if V be the potential applied across the conductor then work done in taking Q coulomb charge from one end of the conductor to another.

$$W = VQ$$

from eqn (1)

$$\boxed{W = VIt} \quad \text{---------- (2)}$$

from ohm's law

$$V = IR$$

then from (2)

$$\boxed{W = I^2Rt} \quad \text{---------- (3)}$$

if the circuit is purely resistive then total work done is converted into heat desipated by the conductor

Hence from eqn (3)

$$H = I^2 R t$$

$$H = \frac{I^2 R t}{4.18} \text{ cal}$$

The above equations is known as **Joule's law of Heating**

According to this law, the heat produced in the conductor is —

- directly proportional to the square of current flowing through the conductor ie

$$H \propto I^2$$

- directly proportional to the resistance R of the conductor ie

$$H \propto R$$

- directly proportional to the time for which the current flows through the conductor ie

$$H \propto t$$

[2] **Electric Power**:- The rate at which work is done by a source of e.m.f in maintaing an electric current through a circuit is called electric power ie

$$P = \frac{W}{t} \quad \text{——(1)}$$

Here P = Power
W = workdone
t = time

OR

The rate at which an appliance converts electrical energy into other form (Heat etc) is called its electric power.

ie

$$P = \frac{H}{t}$$

Here H = Heat

t = time.

Since we know that

$$W = VIt.$$

then from eqn (1)

$$P = \frac{VIt}{t}$$

$$P = VI \quad \text{——— (2)}$$

from eqn (2)

$$P = I^2R$$

{Since $V = IR$}

from eqn (2)

$$P = \frac{V^2}{R}$$

(Since $I = \frac{V}{R}$)

Commercial UNIT of Power Horse Power

1 hp = 746 W

SI unit :- Watt (W)

1 Watt = 1 volt x 1 ampere.

Hence. "electric power of a circuit is said to be 1 watt. if one ampere of current flows through it & P.d of 1 volt is applied across it"

$1\ kW = 10^3 W$

$1\ MW = 10^6 W$

[3] **Electrical Energy:-** The total workdone by the source of emf in maintaing the electric current in the circuit for a given time is called electric energy. Consumed in circuit.

Mathmatically.

$$W = P \times t$$

1 kWh = 3.6×10^6 J

ie Electrical Energy = Electric power x time.

ie the total amount of electrical energy consumed by a electric circuit is given by product of electric Power of the attliances & time for which it is used.

UNIT → S.I unit — Joule. or watt sec.

ie 1 Joule = 1 watt x 1 second.

Another UNIT → Watt hour

1 Watt hour = 1 watt x 1 hour.

Commercial unit of electrical Energy → kilowatt hour

(Board of trade unit [BOT])

1 kilowatt hour = 1 kilowatt x 1 hour

(UNIT)