Electricity

It is a branch of physics where we study about the charge and its effect.

Static Electricity: (Rest) A branch of physics which deals with the study of the electrical charges at rest and their effects is known as electrostatics or static electricity.

Current electricity: (Motion) A branch of physics which deals with the study of the electrical charges in motion and their effects is known as electrostatics or static electricity.

Charge

- It is a physical quantity of matter which causes it to experience a force when placed near other electrically charged matter.
- Its S.I. unit is coulomb (C).
- Quantisation of charge

  $Q = ne$

  Where n = No. of electrons

  e = charge on electron
- The charge on an electron is $\boxed{-1.6 \times 10^{-19}\ \text{C}}$.
- It is a scalar quantity.

Smaller units:

→ $1\mu C = 10^{-6}\ C$

→ $1mC = 10^{-3}\ C$

→ $1MC = 10^{6}\ C$

Electric Current

- The rate of flow of electric charge through a conductor.
- Its S.I. unit is Ampere (A).
- I = Charge/Time = Q/t = ne/t

  1A = 1C/s
- One Ampere: one ampere of current represents on coulomb of electrical charge, i.e., 6.25×10^{18} charge carriers, moving in one second.
- It is a scalar quantity.

Smaller units:

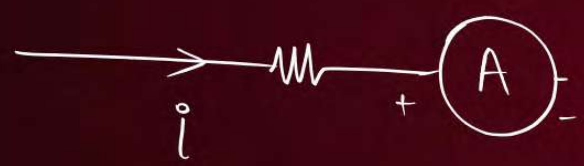
$1\mu A = 10^{-6}$ A

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

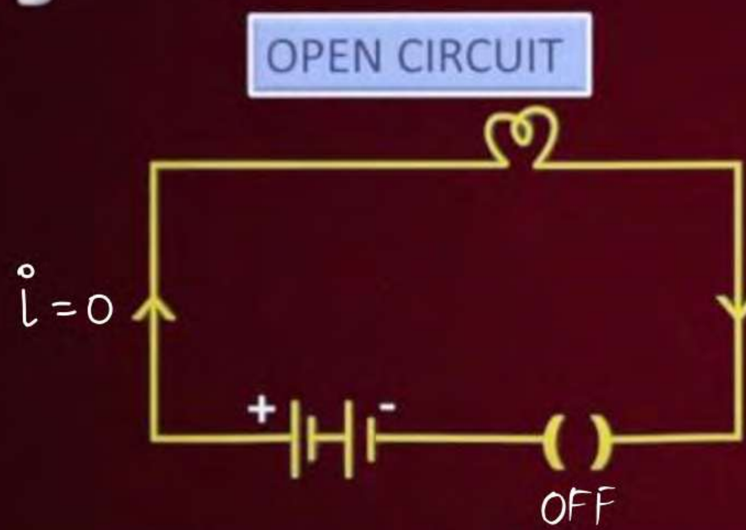
$1MA = 10^{6}$ A

Ammeter

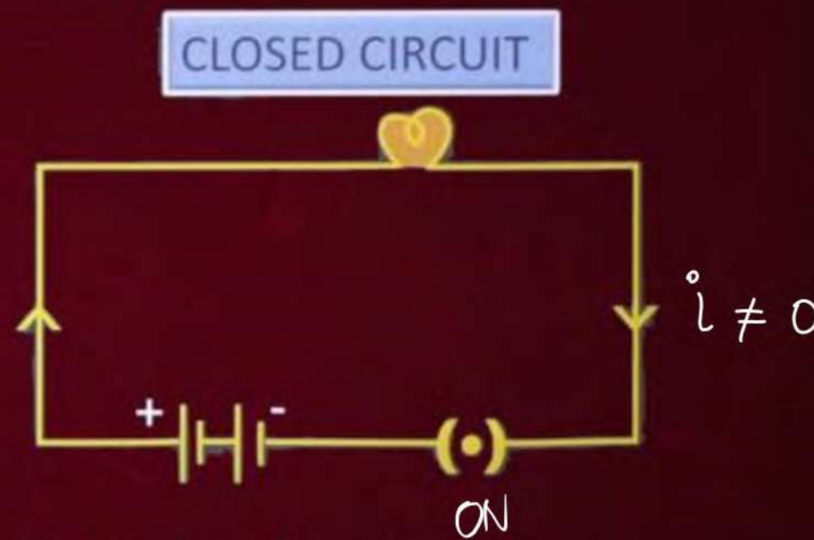
- Measure by an instrument called Ammeter and always connected in series.



Ammeter



- An unclosed/open switch through which electric current does not flows.



- A closed and continuous path through which electric current flows

Potential Difference / Voltage (V)

- Work done on a unit positive charge from one point to other.
- Its S.I unit is Volt (V)
- V = Work done/Charge = W/Q

  $$\Delta v = v_B - v_A$$

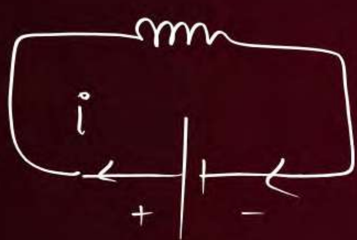
- 1 V = 1 J/C
- **One Volt:** 1 Joule of work is done in bringing 1 coulomb of positive charge from infinity to a point in an electric field, then the potential at that point is 1 volt.
- It is a scalar quantity.

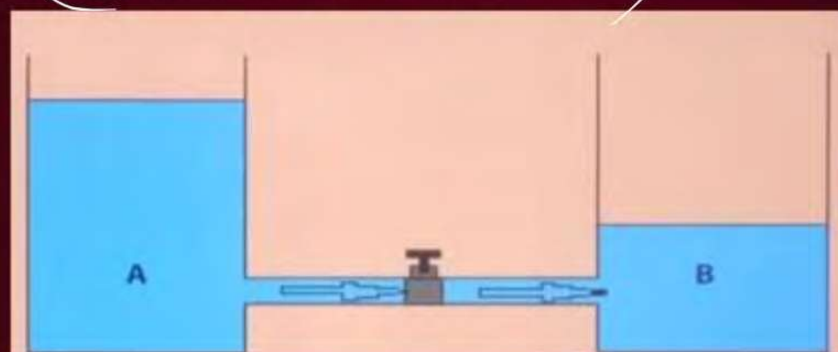
Voltmeter

➢ Measured by an instrument called Voltmeter and always connected in parallel.

Direction of Current

- The water flows from higher level to lower level

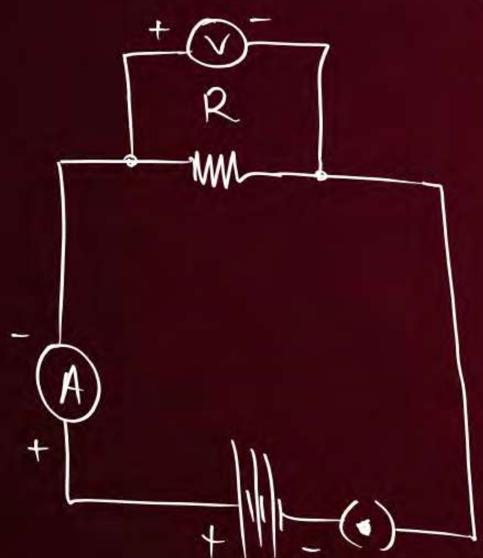




- Positive terminal of battery called higher potential. ✓
- Negative terminal of battery called lower potential. ✓
- Similarly, the direction of current is from higher potential to lower potential i.e., positive to negative.

Conventional Symbols

Simple ckt. diagram
- device
- Wires
- Battery
- Switch



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	or
8.	A resistor of resistance R	
9.	Variable resistance or rheostat	or
10.	Ammeter	
11.	Voltmeter	
12.	Fuse	

OHM's LAW

Voltage $\propto$ Current

$V \propto I$

Basically it is a Relationship between current and voltage.

- The electric current flowing through a conductor is directly proportional to the potential difference across its ends, provided the physical conditions like temperature, pressure, etc. do not change.
- $V \alpha I$

  $\boxed{V = IR}$, Where R = resistance

  constant

Resistance

- The property of a conductor by virtue of which it opposes the flow of electric current through it is called its resistance (R).
- Its S.I. unit is ohm (Ω).
- R = voltage/current = V/I
- It is a scalar quantity.

$$V = IR$$

$$\text{Constant} \leftarrow R = \frac{V}{I}$$

Graphs of Ohmic Conductors

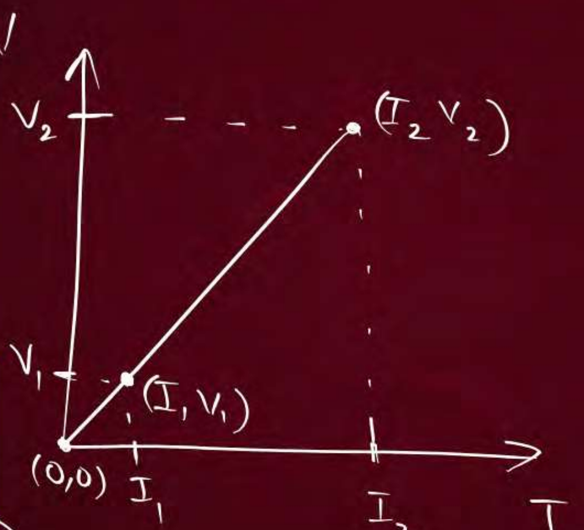
$V \propto I$

$$\text{Slope} = \frac{\Delta y}{\Delta x}$$

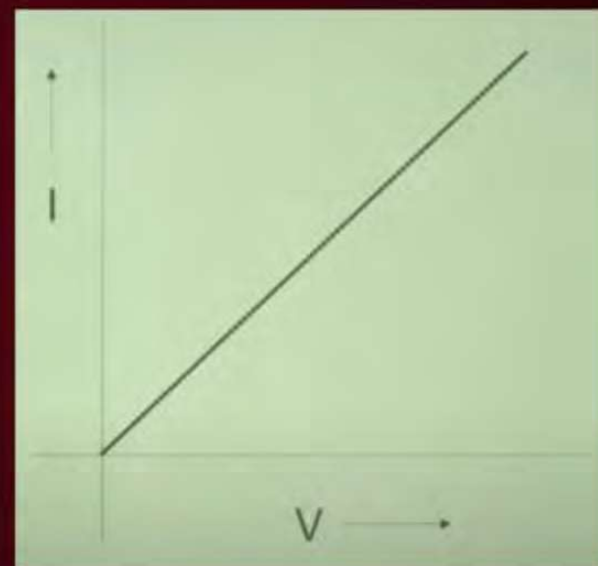
$$= \frac{y_2 - y_1}{x_2 - x_1}$$

$$\boxed{\underset{(V\text{-}I)}{\text{Slope}} = \left(\frac{\Delta V}{\Delta I}\right) = \left(\frac{V_2 - V_1}{I_2 - I_2}\right)}$$

$$= R$$



$I \propto V$



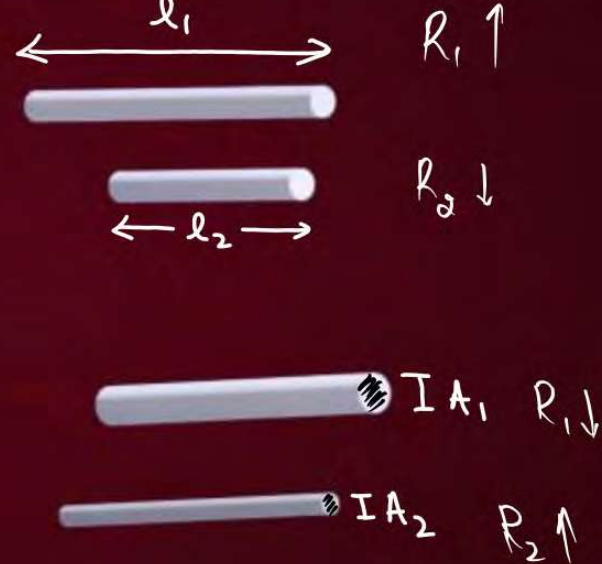
Factors Affecting Resistance

(Lambai)

1. **Length**
   $R \propto l$

(Motai)

2. **Area**
   $R \propto 1/A$



Factors Affecting Resistance

1. **Nature of material** → Resistivity (ρ) → Rho

Conductors: having very less resistance $\downarrow$ $\rho\downarrow$ $i\uparrow$
Semi Conductors: having resistance
Insulators: having very large resistance $\uparrow$ $\rho\uparrow$ $i\downarrow$

2. **Temperatue**

$T\uparrow R\uparrow$

$R\alpha l$
$R\alpha 1/A$
$R\alpha l/A$
$R = \rho\frac{l}{A}$
ρ = Resistivity

$$\left.\begin{array}{l} R \propto l \\ R \propto \frac{1}{A} \end{array}\right\} R \propto \frac{l}{A}$$

$$\boxed{R = \rho\frac{l}{A}}$$

Resistivity

→ Material dependent property

- It refers to resistance of a conductor of unit length and cross sectional area.
- Its S.I. unit is ohm-metre (Ωm).
- It depends upon the nature and temperature.

$$R = \rho \frac{l}{A}$$

put $l = 1m$, $A = 1m^2$

$$R = \rho \frac{1}{1}$$

$$\rho = R$$

Resistivity of Different Materials

Material	Resistivity ρ (ohm m)
Silver	1.59×10^{-8}
Copper	1.68×10^{-8}
Copper, annealed	1.72×10^{-8}
Aluminum	2.65×10^{-8}
Tungsten	5.6×10^{-8}
Iron	9.71×10^{-8}
Platinum	10.6×10^{-8}
Manganin	48.2×10^{-8}
Lead	22×10^{-8}
Mercury	98×10^{-8}
Nichrome (Ni.Fe.Cr alloy)	100×10^{-8}
Constantan	49×10^{-8}
Carbon* (graphite)	$3\text{-}60 \times 10^{-5}$
Germanium*	$1\text{-}500 \times 10^{-3}$
Silicon*	0.1-60---
Glass	$1\text{-}10000 \times 10^{9}$
Quartz (fused)	7.5×10^{17}
Hard rubber	$1\text{-}100 \times 10^{13}$

ρ → Low — Conductors

ρ → Med — Alloy | S.C.

ρ → high — insulator

* SI unit of 'ρ'

$$R = \rho \frac{l}{A}$$

$$\Omega = \rho \frac{\cancel{m}}{m^2}$$

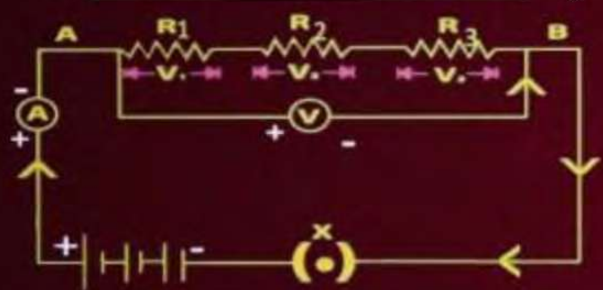
$$\Omega m = \rho$$

Resistance of System

Resistance in Series

i = Same

V = divide

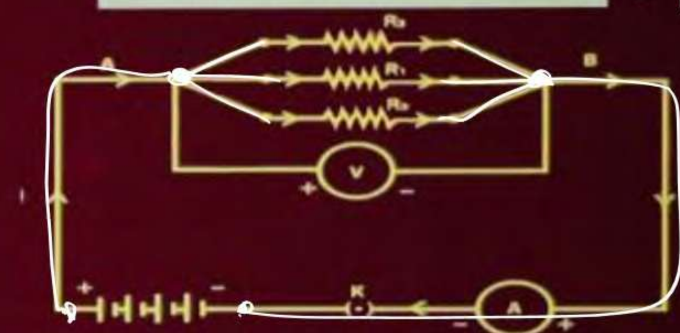


- Maximum effective resistance
- Two/more resistors are connected end to end
- Current remains constant but voltage varies.
- $\boxed{R = R_1 + R_2 + R_3}$

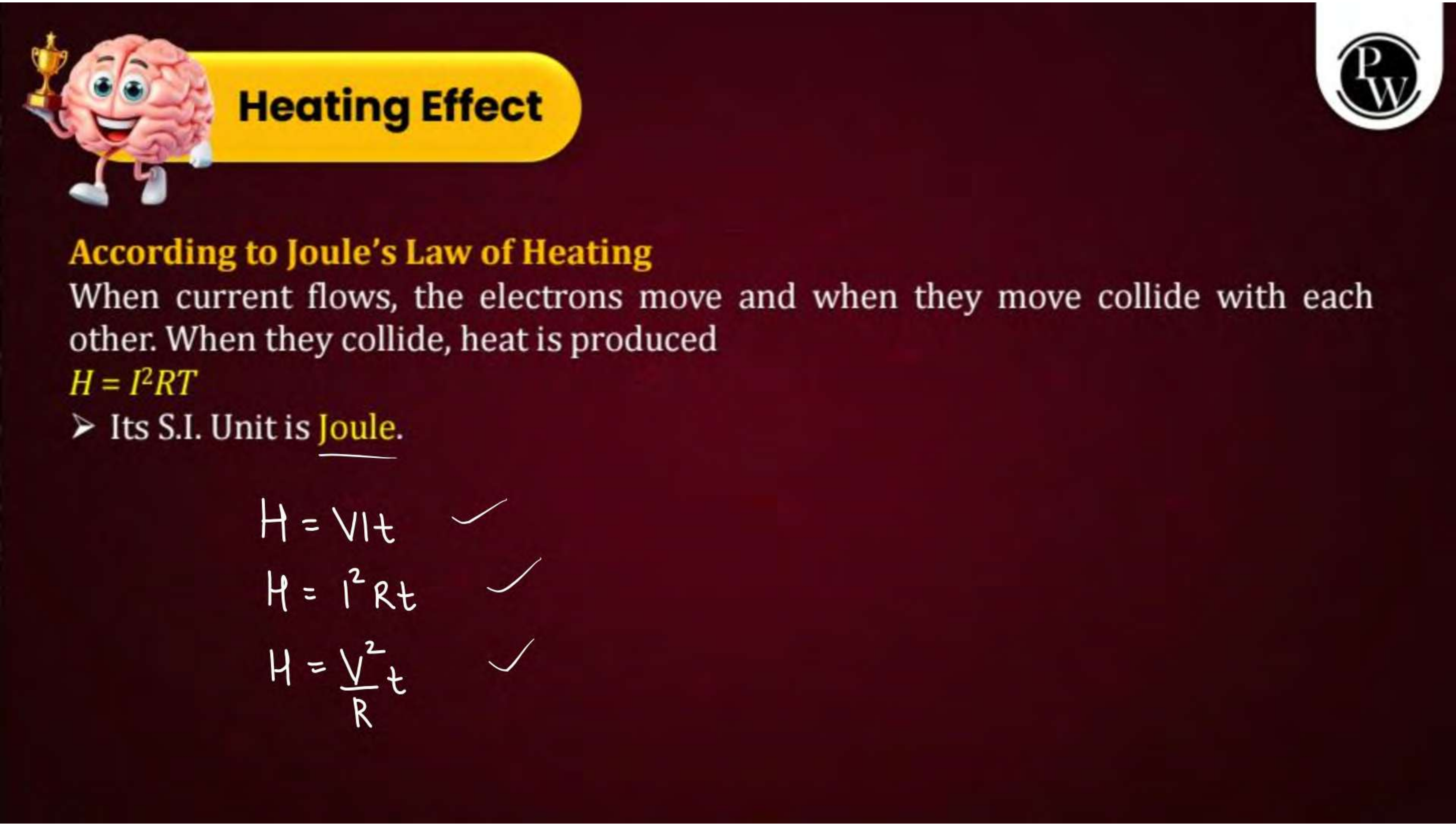
Resistance in Parallel

V = Same

i = divide



- Minimum effective resistance
- Two/more resistors are connected simultaneously between two points
- Voltage remains constant but current varies.
- $\boxed{1/R = 1/R_1 + 1/R_2 + 1/R_3}$


Heating Effect
According to Joule's Law of Heating
When current flows, the electrons move and when they move collide with each other. When they collide, heat is produced
H = I²RT
Its S.I. Unit is Joule.
H = VIt
H = I²Rt
H = V²/R t

Practical Applications of Heating Effect

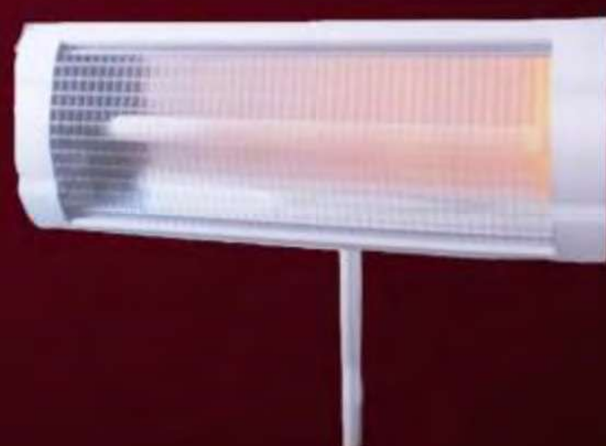
→ Alloy $\rho \uparrow$ $R \uparrow$ $H \uparrow$

Electrical Appliances (Nichrome wire is used)

↳ heating element

Iron

Heater



Partical Applications of Heating Effect

Bulb (Tungsten wire is used)

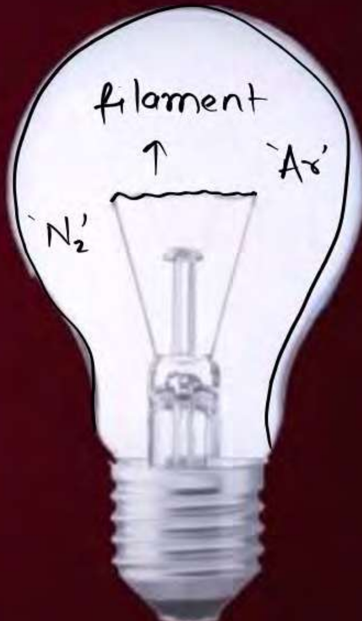
filament

R ↑ H ↑

Very high M.P. ↑
(3380°c)

Heat Retention ↑

Glow



Partical Applications of Heating Effect

($Pb + Sn$)

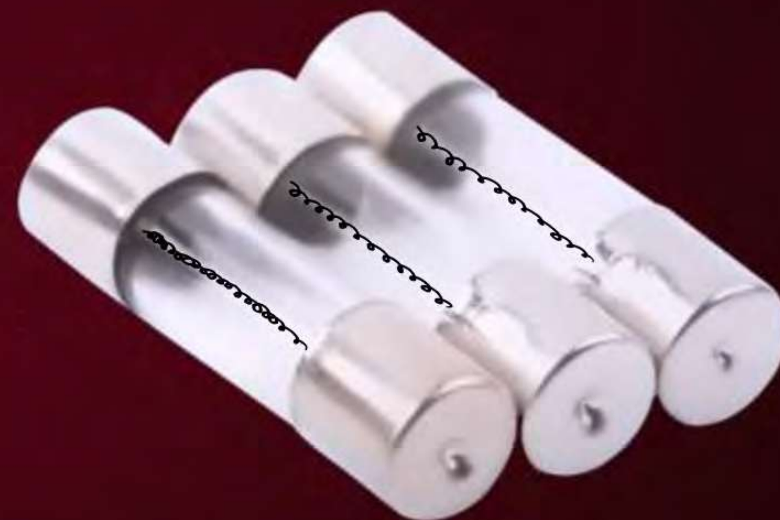
Fuse (alloy of lead and tin is used)

Fuse Wire

M.P. low ⇒ Wire melts

Current overload

Ckt. breaks



Electric Power

IX $\boxed{P = \frac{W}{t} = \frac{\varepsilon}{t}}$

- The rate at which electric energy is dissipated or consumed in an electric circuit.
- Its S.I. Unit is Watt.
- Power = energy/time = $VI = I^2R = V^2/R$

  1 Horsepower = 746 watts
- Commercial unit of electric energy is kWh.

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

* All Formulae + Units

$Q = ne$

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

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

$V = IR$

$R = \rho \frac{l}{A}$

Slope (V-I) $= \frac{\Delta V}{\Delta I}$

Slope (V-I) $= R$

$R_s = R_1 + R_2 + R_3 \ldots$

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

$P = \frac{E}{t} \longrightarrow E = P \times t$

$P = VI$ | $E = VIt$

$P = I^2 R$ | $E = I^2 R t$

$P = \frac{V^2}{R}$ | $E = \frac{V^2}{R} t$

SI UNITS :-

- I – Ampere
- W/E → Joule
- R → ohm
- l → m
- Commercial unit of Energy – kWh
- Q – Coulomb
- V – Volt
- P → Watt
- ρ → ohm-metre
- A → m^2