If V is the potential difference across the resistor,

then, $V = IR$ —— (2)

Now, work done to transfer charge(q) from A to B is given as,

$$\text{work } (W) = qV \quad \text{—— (3)}$$

From, eqns. (1), (2) & (3), we get,

$$W = It \cdot IR$$

$$\therefore W = I^2Rt$$

since, electrical energy is converted into heat energy.

$$\therefore \boxed{\text{Heat developed } (H) = I^2Rt} \quad \text{—— (4)}$$

Electrical power (P) :→ Electrical power is defined as the rate at which the work is done to maintain the steady current in an electrical circuit.

i.e. Electrical power $(P) = \frac{W}{t}$

$$= \frac{I^2Rt}{t}$$

$$\therefore \boxed{P = I^2R} \quad \text{—— (1)}$$

$$\boxed{P = \frac{V^2}{R}} \quad \text{—— (2)} \left(\because I = \frac{V}{R}\right)$$

$$\therefore \boxed{P = IV} \quad \text{—— (3)} \ (\because V = IR)$$

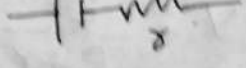
Imp **Electromotive force (Emf) :->** The emf of a cell is defined as the energy supplied by the source to the charge to move through an ~~air~~ electrical circuit.

The emf of a cell is the potential difference between two terminals of the cell in open circuit.

SI unit of E is volt(V).

Internal resistance (r) :-> The resistance offered by the source itself to the flow of current through it.

It is denoted by r.

In electrical circuit, the internal resistance is written as, 

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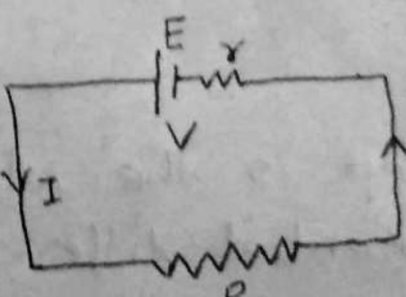
Terminal potential difference (V) :-> The potential difference between two terminals of a cell in a closed circuit is called terminal potential difference.

The terminal potential difference is equal to the potential difference across external resistance in a circuit.

Its SI unit is volt (V)

V. Imp **Relation between emf (E), terminal p.d. (V) and internal resistance (r) :->**



Let, a cell of emf E and internal resistance r is connected in series with an external resistance R as shown in fig.

let, I is the current flowing in the circuit.

Then
$$E = IR + Ir$$
$$E = I(R+r)$$
$$\therefore I = \frac{E}{R+r} \quad \text{——— (1)}$$

since, terminal potential difference is equal to the potential difference across external resistance.

Then, terminal p.d. (V) = IR

$$\therefore V = \frac{E}{R+r} \times R$$
$$\therefore \frac{R+r}{R} = \frac{E}{V}$$
$$\text{or, } 1 + \frac{r}{R} = \frac{E}{V}$$
$$\text{or, } \frac{r}{R} = \frac{E}{V} - 1$$
$$\text{or, } \frac{r}{R} = \frac{E-V}{V}$$
$$\therefore \boxed{r = \frac{(E-V)R}{V}} \quad \text{——— (2)}$$

This is the relation between emf (E), terminal potential difference (V) and internal resistance (r).

unit:-7.8: Resistance and heat

Joule's law of heating :-

According to Joule, the heat developed in a conductor due to flow of current is,

i) directly proportional to the square of current

i.e. $H \propto I^2$ —— (1)

ii) directly proportional to the resistance of conductor.

i.e. $H \propto R$ —— (2)

iii) directly proportional to the time for which current flows

i.e. $H \propto t$ —— (3)

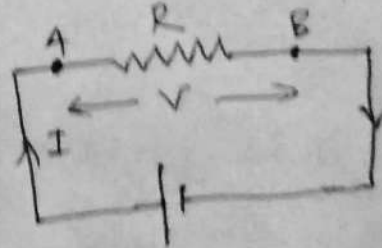
combining eqns (1), (2) & (3), we get,

$$H \propto I^2 R t$$

$$\therefore \boxed{H = \frac{I^2 R t}{J}} \quad \text{—— (4)}$$

where, J is constant known as Joule's mechanical equivalent of heat. J is conversion factor and its value is 4.18 Joule calory^{-1}.

Expression of heat developed in a wire :-



Suppose, a resistance R between two points A and B as shown in fig. Let, I be the current flowing through it in a time t then,

$$I = \frac{q}{t} \quad ; \text{ where, } q = \text{charge}$$

$$\therefore q = It \quad \text{—— (1)}$$