

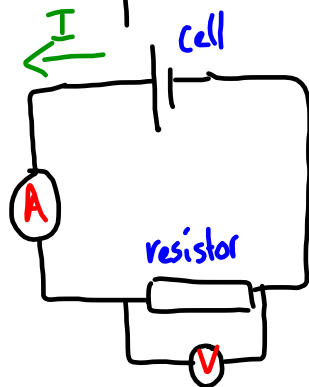
To finish up background on Electric Currents:

Ammeter

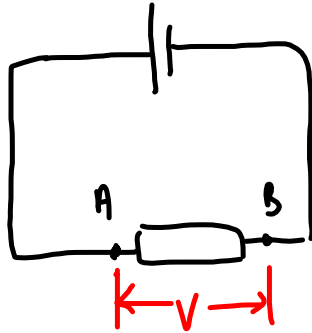
- an ammeter measures the current in amps at a point in the circuit.
- measures the number of coulombs of charge passing through it every second
- it is placed in series in the circuit at point where the current is to be measured

Voltmeter

- measures the energy in joules which is converted into other energy forms by each coulomb of charge as it passes between two points. An energy difference per unit charge is called the potential difference
- think of the voltmeter as an "energy sensor". It measures the difference in electrical potential energy between two points of each coulomb of charge as it moves between those points.
- it is calibrated in volts $1V = 1J C^{-1}$
- it is placed in parallel in the circuit



Electric potential difference (V)



$$V = \frac{\Delta E_p}{q}$$

symbol

units: $1V = 1JC^{-1}$

↑
the unit for volt

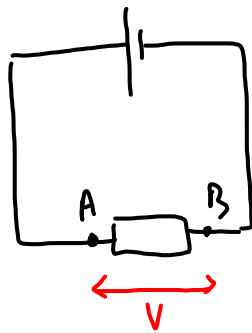
scalar quantity.

Test Charge

- hypothetical charge used to define certain quantities

Potential Difference should be used rather than voltage

Consider a positive test charge moving from A to B:



work is done to move the charge (test) from A to B. Recall work is equal to the change in energy.

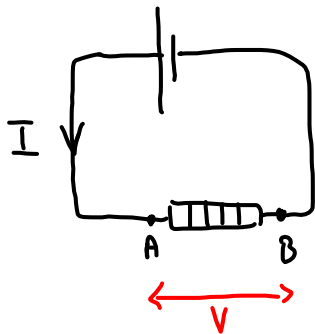
$$V = \frac{\Delta \bar{E}_p}{q}$$

← change in potential energy

$$V = \frac{\Delta W}{q}$$

← work

Change in Potential Energy



$$V = \frac{\Delta \bar{E}_p}{q} \text{ (definition)}$$

$$\Delta \bar{E}_p = qV$$

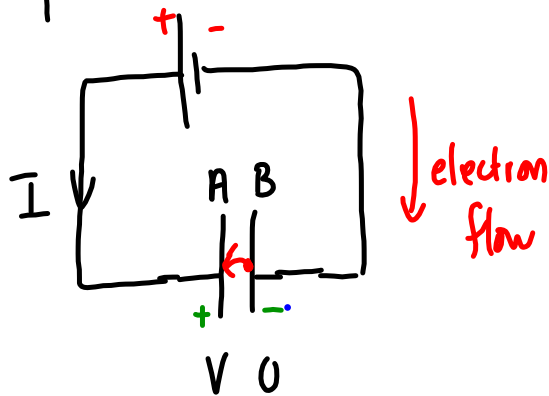
$$\Delta \bar{E}_p = VI\Delta t$$

recall: $I = \frac{\Delta q}{\Delta t}$
 $\Delta q = I\Delta t$

the loss in potential energy \Rightarrow heating the resistor (thermal energy)

* This is the internal energy which is generated in the heating element (resistor) in time Δt

Suppose that instead of a resistor, that we have two parallel plates separated in a vacuum:



Suppose an electron of charge e released from rest and it moves toward A.

at B, the electron has potential energy

$$E_p = eV, \quad E_k = 0$$

The total energy of the electron is the same at A and B.

$$\therefore eV = \frac{1}{2}mv^2$$

at A, the electron has no potential energy but has kinetic energy

$$E_p = 0, \quad E_k = \frac{1}{2}mv^2$$

where e is the elementary charge

V is the potential difference.

m is the mass of the electron

v is the speed of the electron as it strikes plate A

Example

A current 5.0A flows for 30s through an electric heating V element which has a potential difference across it of 8.0V

a) How much charge flows through the element in 30s ?

$$I = 5.0\text{A}$$

$$\Delta t = 30\text{s}$$

$$\Delta q = ?$$

$$I = \frac{\Delta q}{\Delta t}$$

$$\Delta q = I \Delta t$$

$$\Delta q = (5.0\text{A})(30\text{s})$$

$$\Delta q = 150\text{C}$$

units

$$(\text{C s}^{-1})(\text{s}) = \text{C}$$

b) What is the loss in electrical potential energy of this charge in 30s ?

$$V = \frac{\Delta E_p}{q} \quad (\text{definition})$$

$$\Delta E_p = qV \quad (\text{C})(\text{J C}^{-1}) = \text{J}$$

$$\Delta E_p = (150\text{C})(8.0\text{V})$$

$$\Delta E_p = 1200\text{J}$$

c) How much internal energy is generated in the heating element?

loss of potential energy
gain in internal energy
1200J of internal energy

d) How much power is generated in the heating element?

$$P = \frac{\Delta E_p}{\Delta t}$$

$$P = \frac{1200\text{J}}{30\text{s}}$$

$$P = 40\text{W}$$

