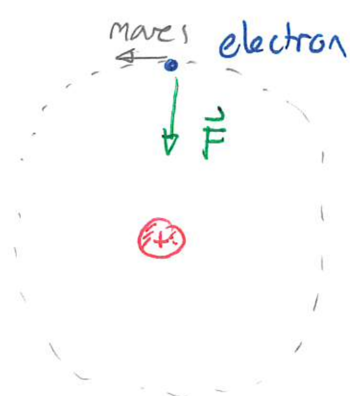
Fri: HW by 5pm

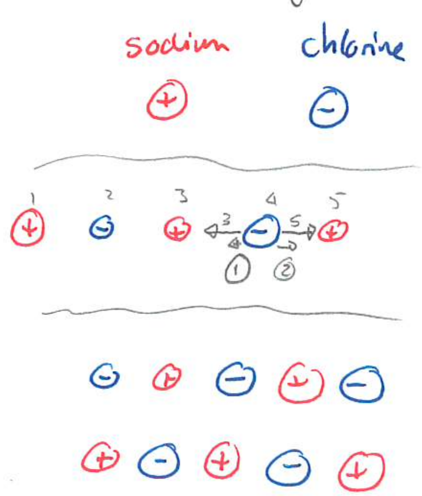
Monday: Read 8.4

Electric forces and atoms / materials

We can use electric forces to begin to describe how atoms work. The simplest example is a hydrogen atom that consists of a single proton and a single electron. There is an attractive force inwards to the nucleus on the electron. This is the force that is required to keep the electron in a circular orbit. In the absence of this force it would fly off tangentially from the atom.



Similarly one can describe how certain bulk substances are structured. In table salt (sodium chloride) the atoms exchange electrons so that the sodium becomes a positive ion and the chlorine negative. These can then exert attractive forces that are balance in a regular array.



⇒ attractive force causes collapse

⇒ forces on central sodium balance but not on others

} entire lattice ⇒ cancelling forces

DEMO: ChemTube 3D

Moving charges / currents

So far we have mostly considered stationary charges. However, it is also possible to construct a collection of charges that move. We then refer to:

> An electric current = collection of moving charged particles

There are many ways to create and sustain an electric current. A common way involves electric circuitry.

DEMO: PhET Circuit Construction DC

* Show simple bulb circuit

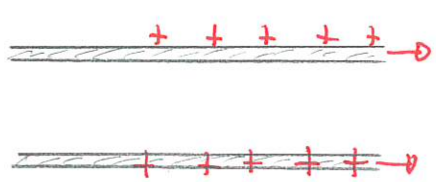
This type of circuit operates by having charged particles flow through the wires and the circuit elements. These moving charges constitute a current.

Quiz 1 90%

Quiz 2 80%

Quiz 3 90%

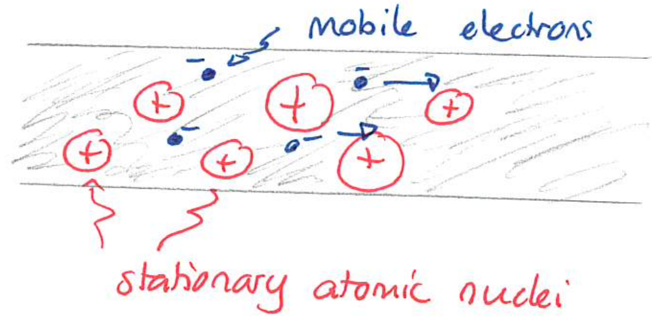
In general the wires in such circuits are neutral. If they were charged then two identically arranged wires must have the same charge.



Quiz 4

These wires would repel. But they are actually observed to attract! So they are likely not charged. We will explain these forces later. We then have the following model for a current in a wire:

- the nuclei are positive an stationary.
- some electrons move. and these constitute the current.



Quantifying current.

Current can be quantified and measured. We could do this in a circuit as follows:

① observe charge flowing through a cross sectional area (window) in the wire.

② Measure the charge Q that flows in time T

③ Then the current is:

$$\text{current} = \frac{\text{charge}}{\text{time}}$$

$$I = \frac{Q}{T}$$ ← coulombs (Q), ← seconds (T)

Units: Amperes (Amps) ≃ A

This is the meaning of the current encountered in various household devices.

1 Electric current

Electric current in circuits consists of moving electrons. Each electron has charge -1.6×10^{-19} C. One might ask how many electrons pass through a household device in a given time. In the following, you can ignore the minus sign (it eventually relates to the direction of current).

a) Suppose that one million electrons flow through a device in five minutes. Determine the total charge that flows through the device in this time and use this to determine the current flowing through the device.

b) Suppose that one billion electrons flow through a device in five seconds. Determine the total charge that flows through the device in this time and use this to determine the current flowing through the device.

The current that flows through a typical toaster is about 8 A.

c) Guess the number of electrons that flow through the toaster in one minute|

d) Determine the total charge that flows through the toaster in one minute|

e) Determine the number of electrons that flow through the toaster in one minute. How does it compare to your guess?

Answer: a) Total charge = number electrons x charge each electron

$$= 1000000 \times 1.6\times10^{-19}C$$

$$= 10^{6}\times 1.6\times10^{-19}C = 1.6\times10^{-13}C$$

$$\text{Current} = \frac{\text{charge}}{\text{time}} = \frac{1.6\times10^{-13}C}{5\times60s} = \frac{1.6\times10^{-13}C}{300s} = 5.3\times10^{-16}A$$

b) $\text{Total charge} = 10^{9}\times 1.6\times10^{-19}C = 1.6\times10^{-10}C$

$$\text{current} = \frac{\text{charge}}{\text{time}} = \frac{1.6\times10^{-10}C}{5s} = 3.2\times10^{-11}A$$

c) must be large

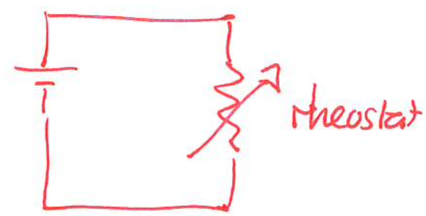
d) $\text{current} = \frac{\text{charge}}{\text{time}} \Rightarrow 8A = \frac{\text{charge}}{60s}$

$$\Rightarrow 8A\times60s = \text{charge} \Rightarrow \text{charge} = 480C$$

e) $\text{number of electrons} = \frac{\text{total charge}}{\text{charge one electron}} = \frac{480C}{1.6\times10^{-19}C} = \boxed{3\times10^{21}}$

Current in electric circuits can be measured relatively easily using a device called a multimeter.

Demo: Create circuit + use multimeter.



We can use this model to describe how a toaster might work.

1. electrons flow through the toaster filament
2. the electrons collide with the nuclei in the filament.
3. during collisions they transfer energy to the nuclei
4. the nuclei vibrate more ⇒ higher temperature.