Unit 6. Electricity

6.1Electricity

6.2 Electric current

6.3 Electric magnitudes

6.4 Ohm´s law

6.5 Electric Circuit

- Elements
- Symbols

6.6 Electric Associations

6.7 Electric energy production

6.8 Electric Power

6.1 The electricity

What would happen if we didn't have electricity?

6.1 Electricity

1º Exercise: Write down a list of 20 objects that use electricity

6.1 Electricity

However we have to remember that we can decrease the amount of energy that we waste everyday, helping our sustainable development.

6.1 Electricity

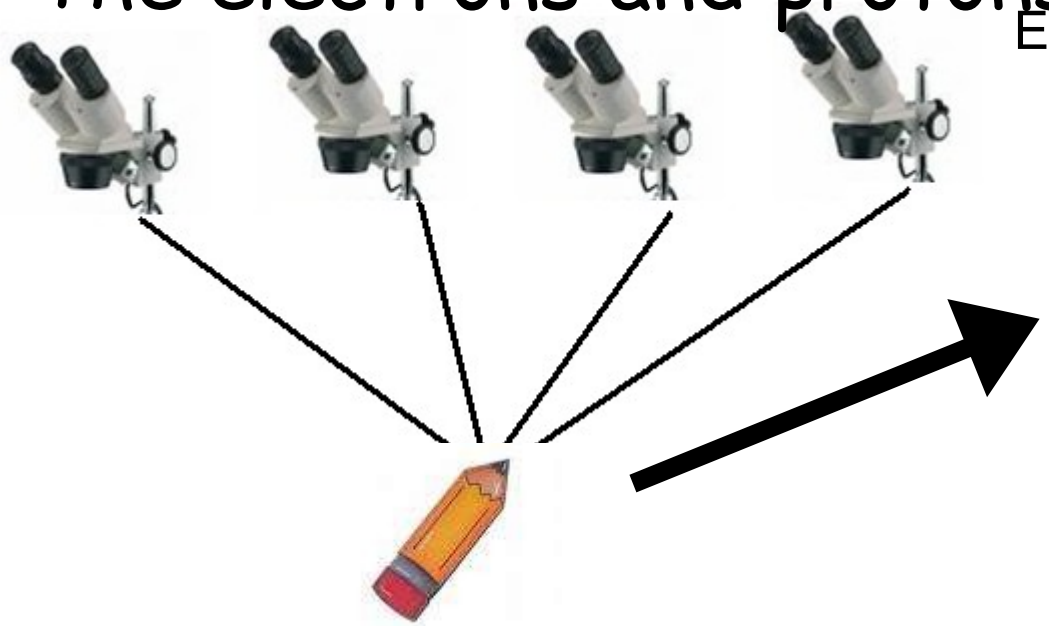
But, what is electricity?

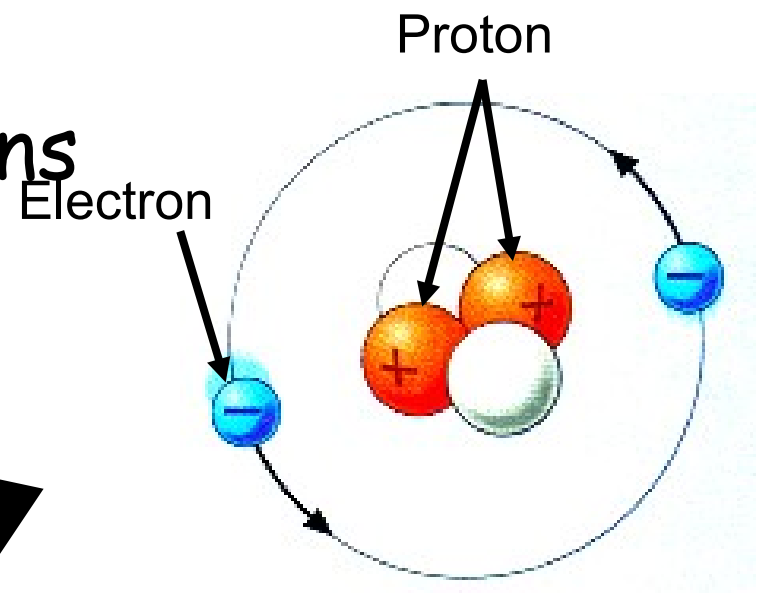
The concept of ***electricity*** includes all the phenomena related to the electric charges

6.1 Electricity

Matter is formed by **atoms**, which contain inside smaller particles with electric charges:

The electrons and protons

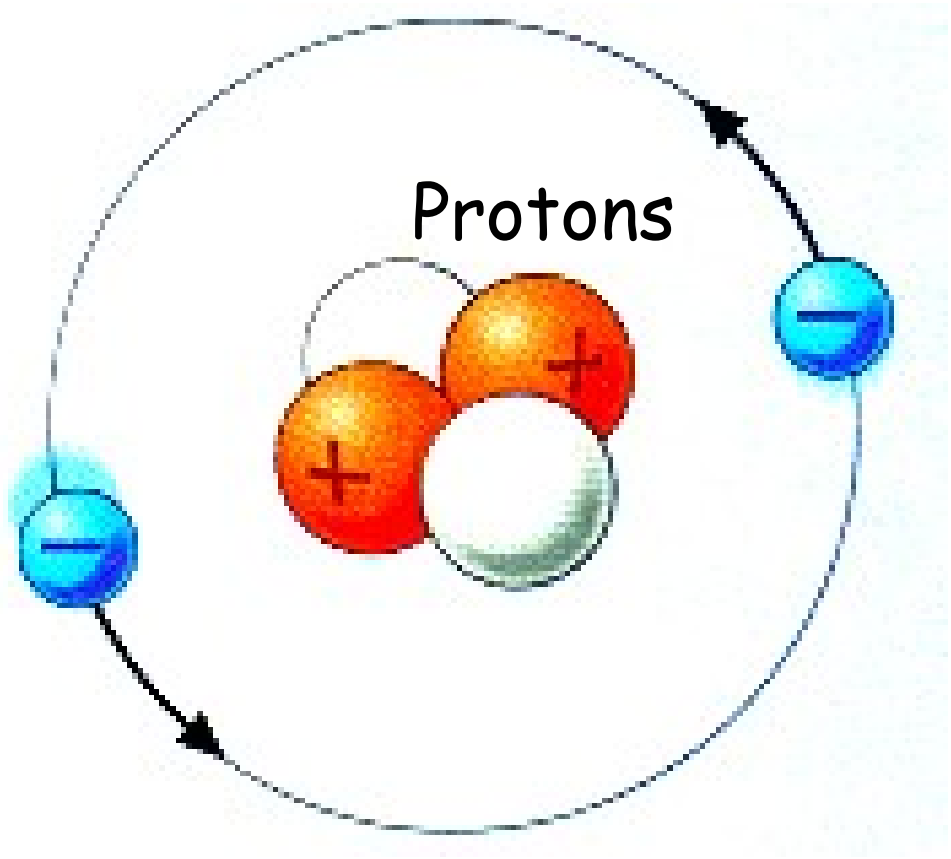




Atom

6.1 Electricity

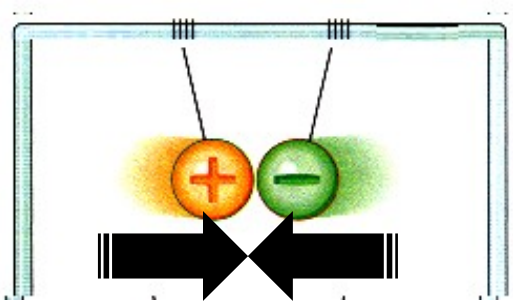
Electrons and protons have **negative** and **positive** charges respectively



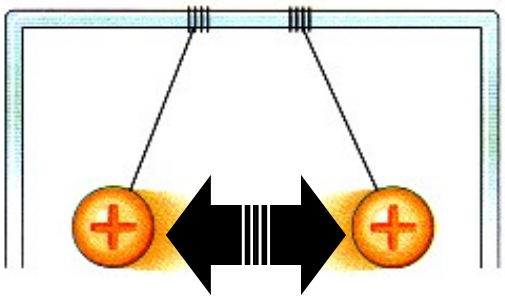
6.1 Electricity

These charges create forces between them that can be attraction or repulsion forces according to the value of the charge:

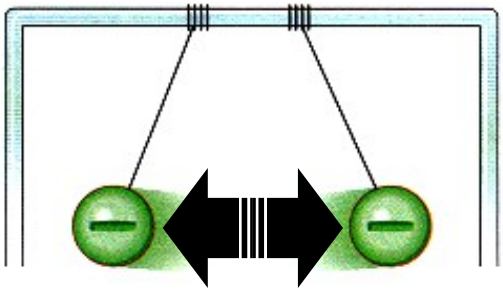
Equal charges: repulsion



attraction



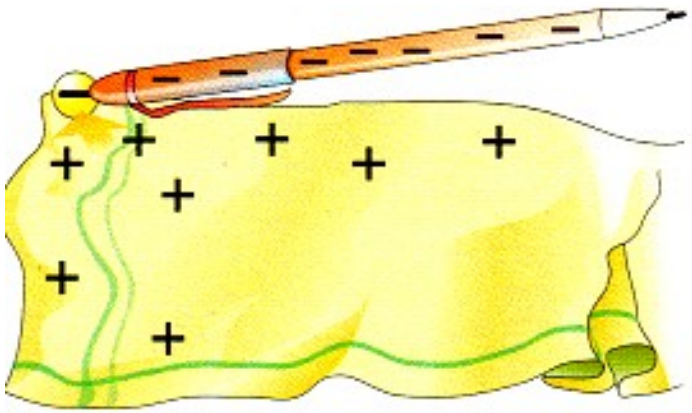
repulsion

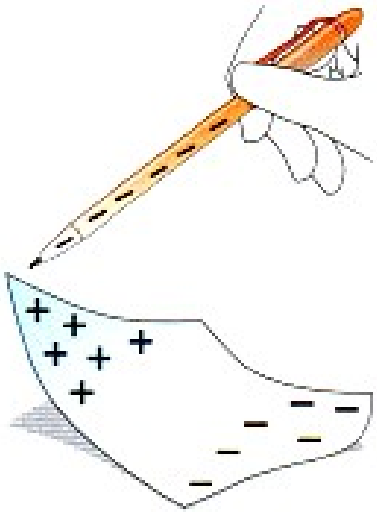


repulsion

6.1 Electricity

Matter can be electrically charged when the charge distribution is upset





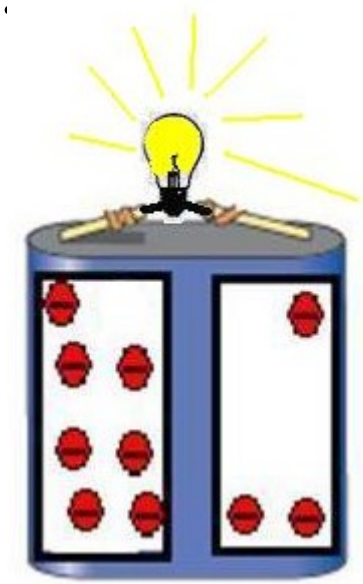
For example, we can change the charge distribution of a pen by rubbing it against your hair. Then you can attract

6.2 Electric currents

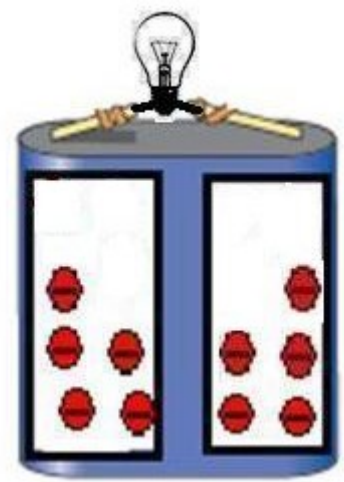
<u>How can we move the charges?</u>

If we want to move the electric charges we have to create a charge upset between

ents and then connect them



Charge upset

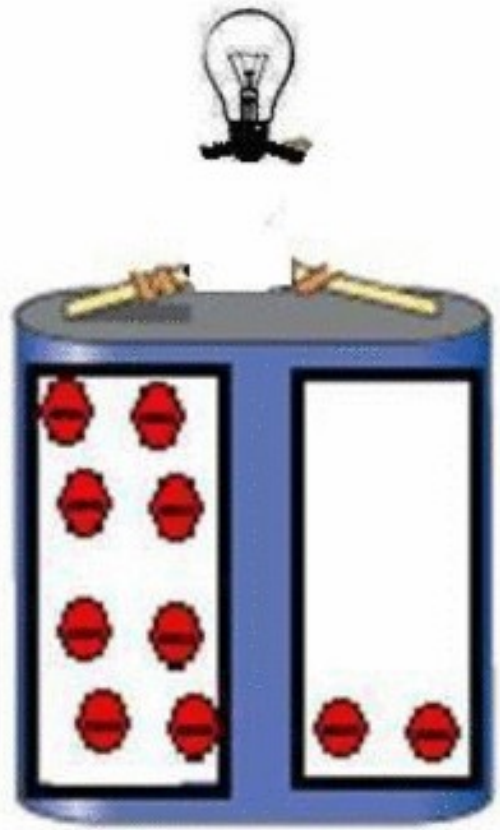


Charge equilibrium

6.2 Electric currents

<u>How can we move the charges?</u>

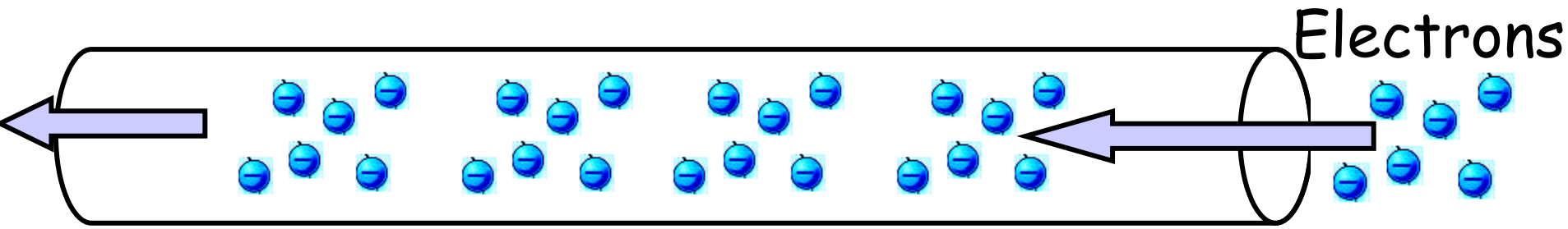
For example, a battery has a pole with more negative charges, so when we connect them the charges start moving in order to balance themselves



We are creating an electric current

6.2 Electric currents

We can make all the charges move continuously through a matter, creating an electric current.

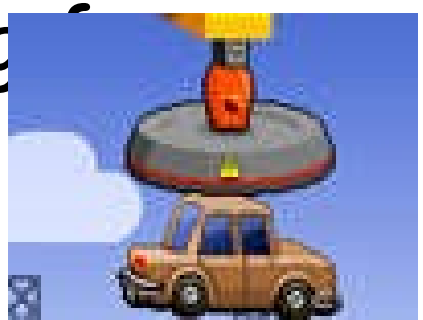


The **<u>electric current</u>** is the displacement of the electrical charges (electrons)

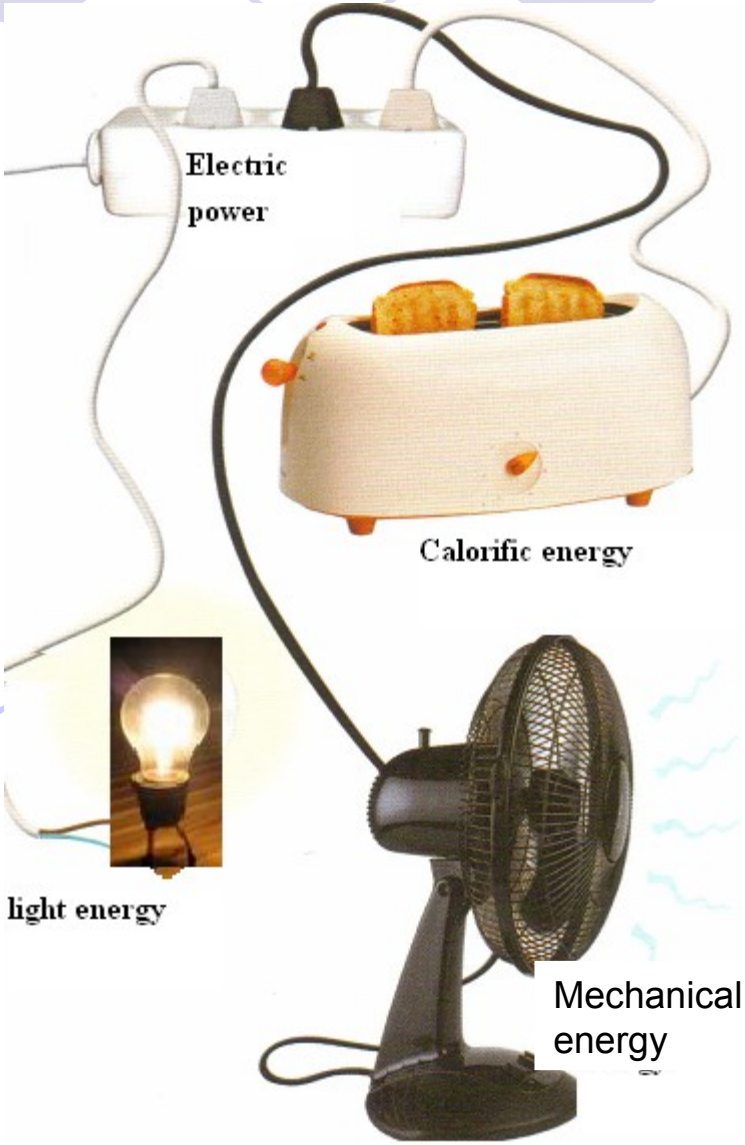
6.2 Electric currents

<u>What is the electric current used for?</u>

Thanks to the charges' movement we can transform electric energy into other energies that are more interesting:

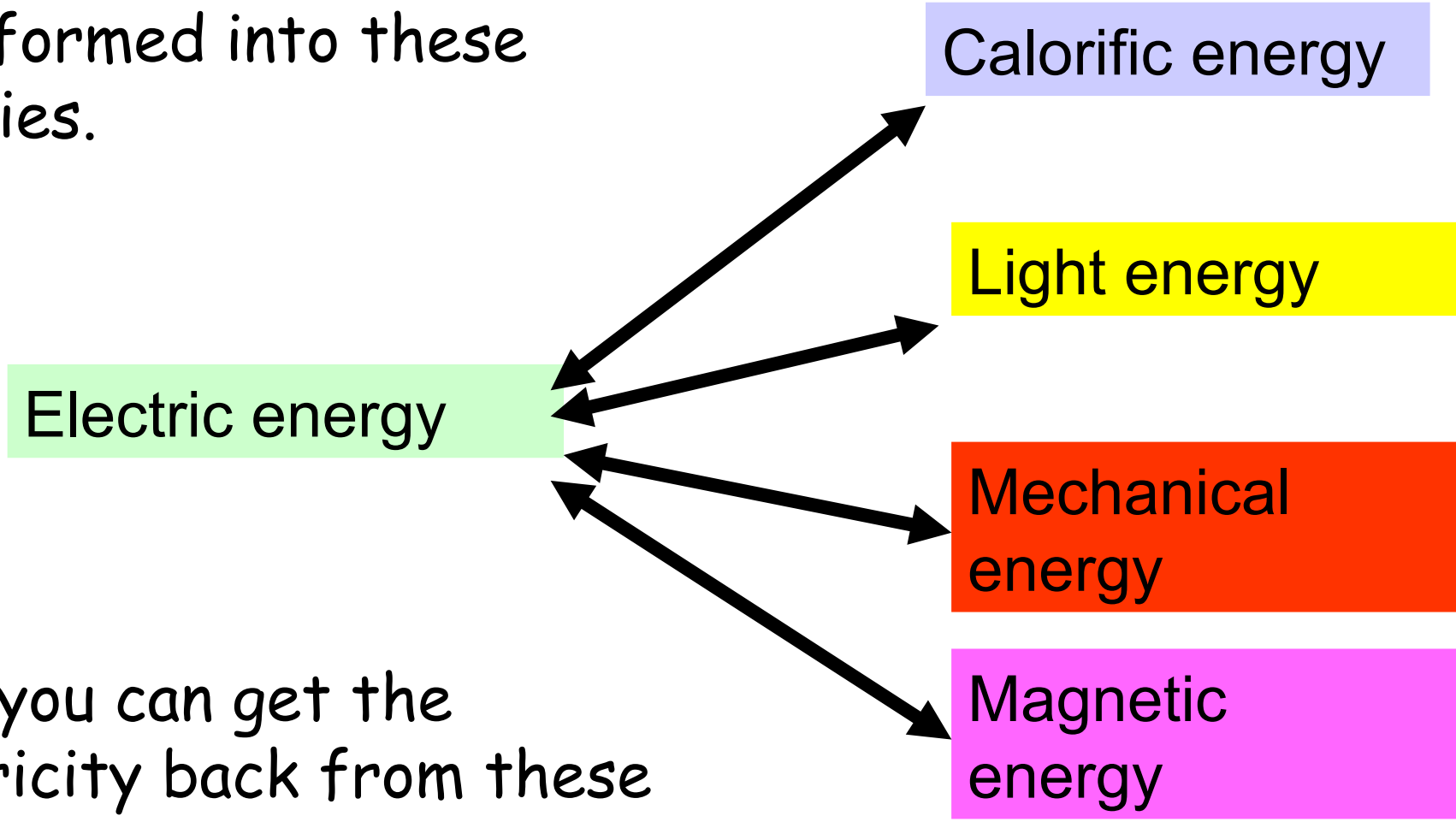


Magnetic energy



6.2 Electric currents

The electric current can be transformed into these energies.



Also, you can get the electricity back from these energies, so, it is reversible energy.

Exercise. Homework

2º Exercise

You have to look for all the electric machines that you have at home. Write down their names and which energy they use.

Ten at least

Electric machine	Energy
Cooker	Calorofic energy

6.3 Electric magnitudes

In order to understand electricity we have to know first the main electric magnitudes:

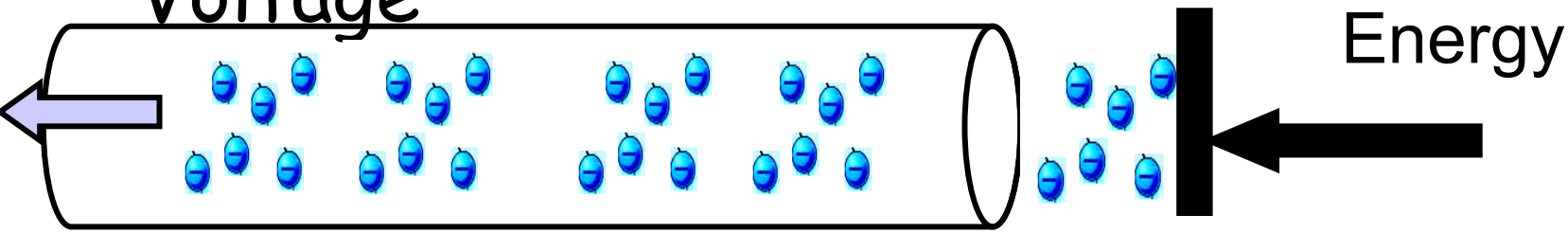
VOLTAGE

INTENSITY

Resistance

6.3 Electric magnitude. Voltage

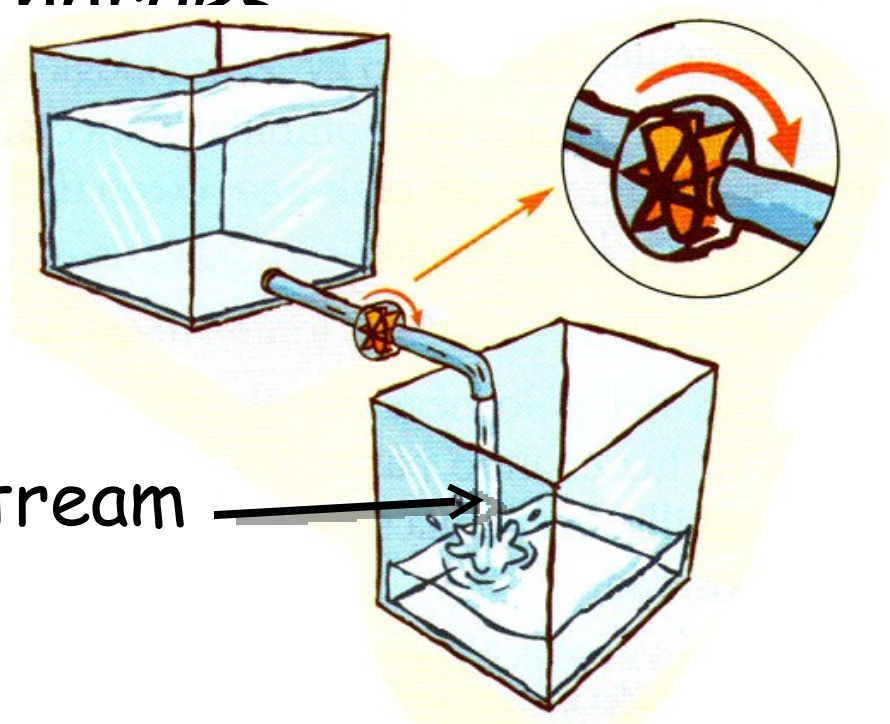
The electrons need energy to be able to move through a material, this is the Voltage



We define the Voltage as the energy per charge unit that makes them flow through a material. This magnitude is measured in Volts.

6.2 The electric current

To better understand the concept of the electric current we can think of it as a stream where the drops are the electric charges

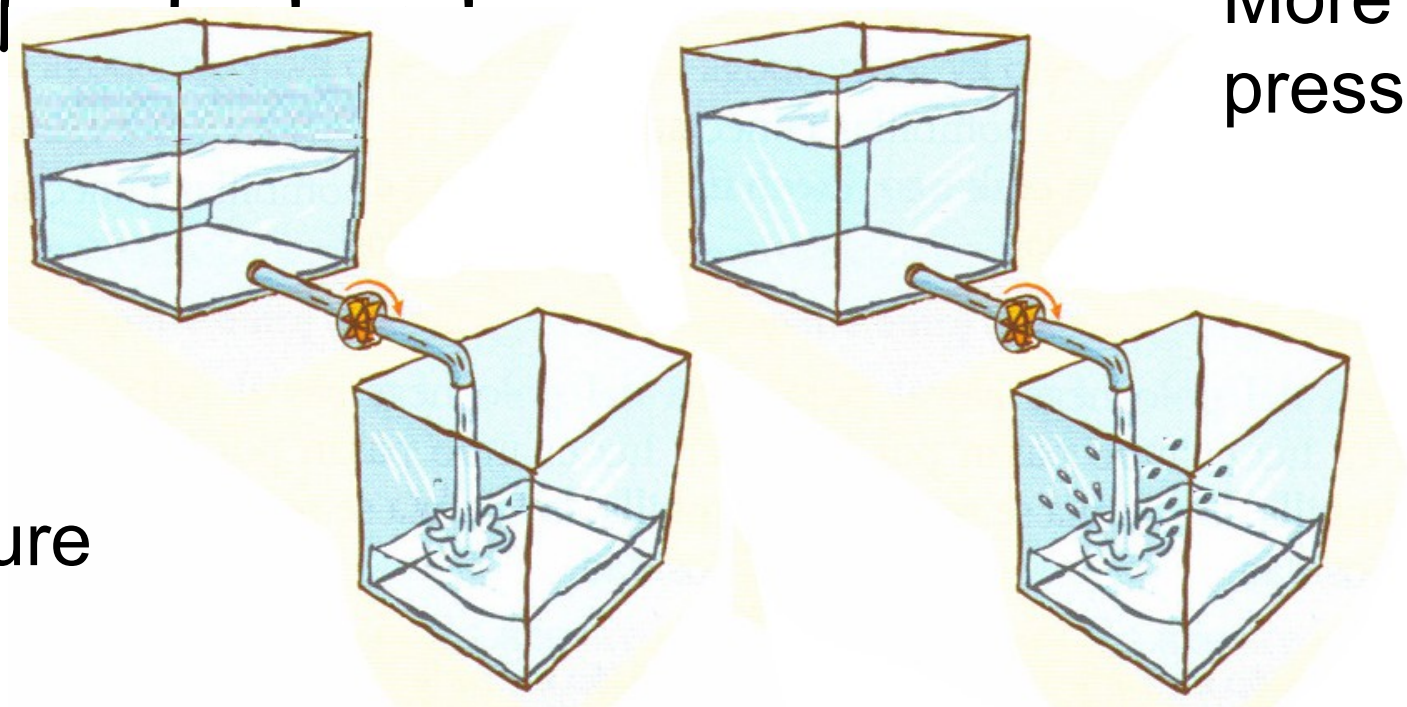


We use the water power from the drops' movement to create energy, as the electrons do.

6.3 Electric magnitude. Voltage

We can see that the stream will have more strength if there is more water in the tank. It's similar to what happened to tl

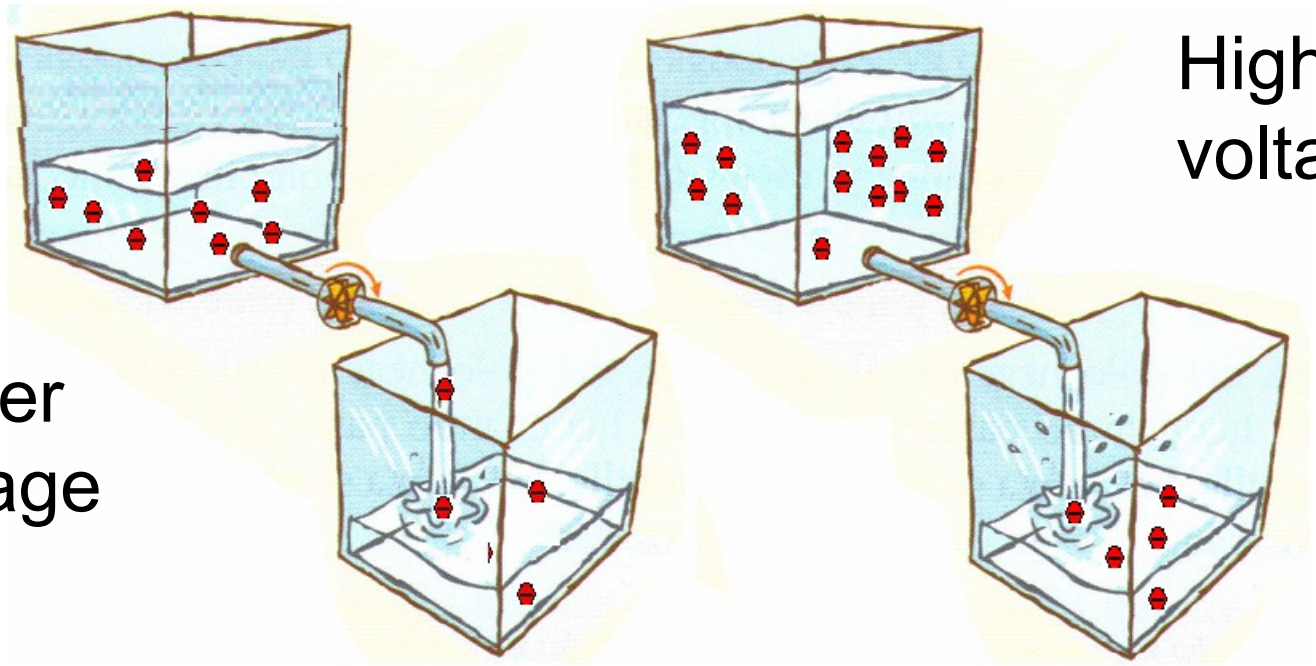
More water pressure



Less water pressure

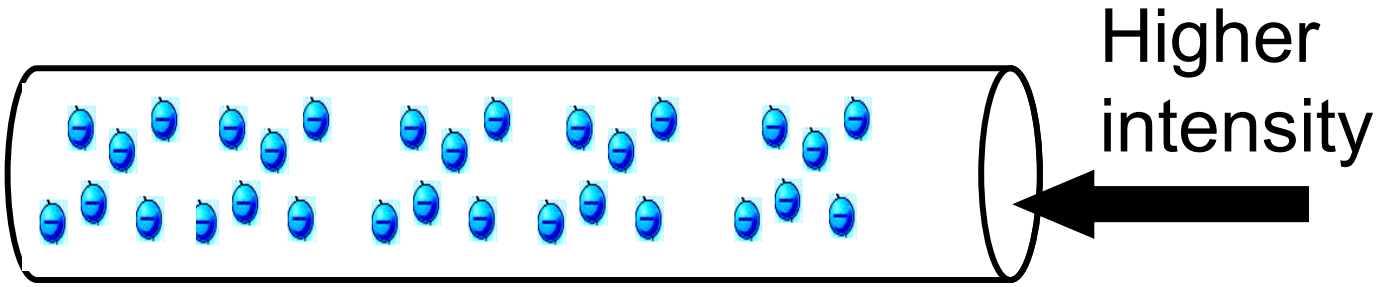
6.3 Electric magnitude. Voltage

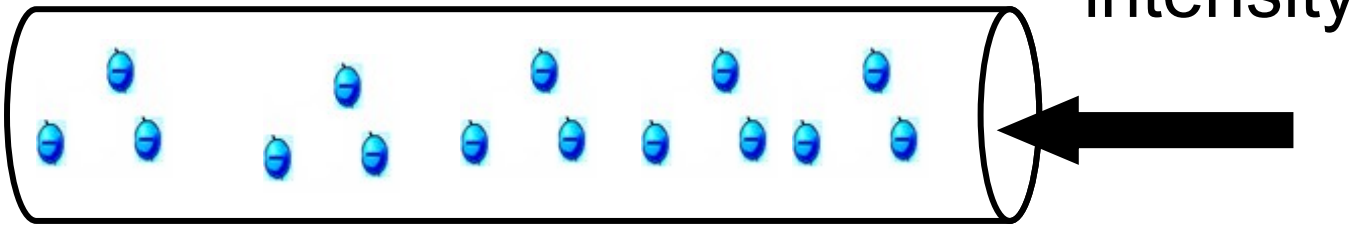
The higher the Voltage is the more energy the electric charges will have to keep on moving



6.3 Electric magnitude. Intensity

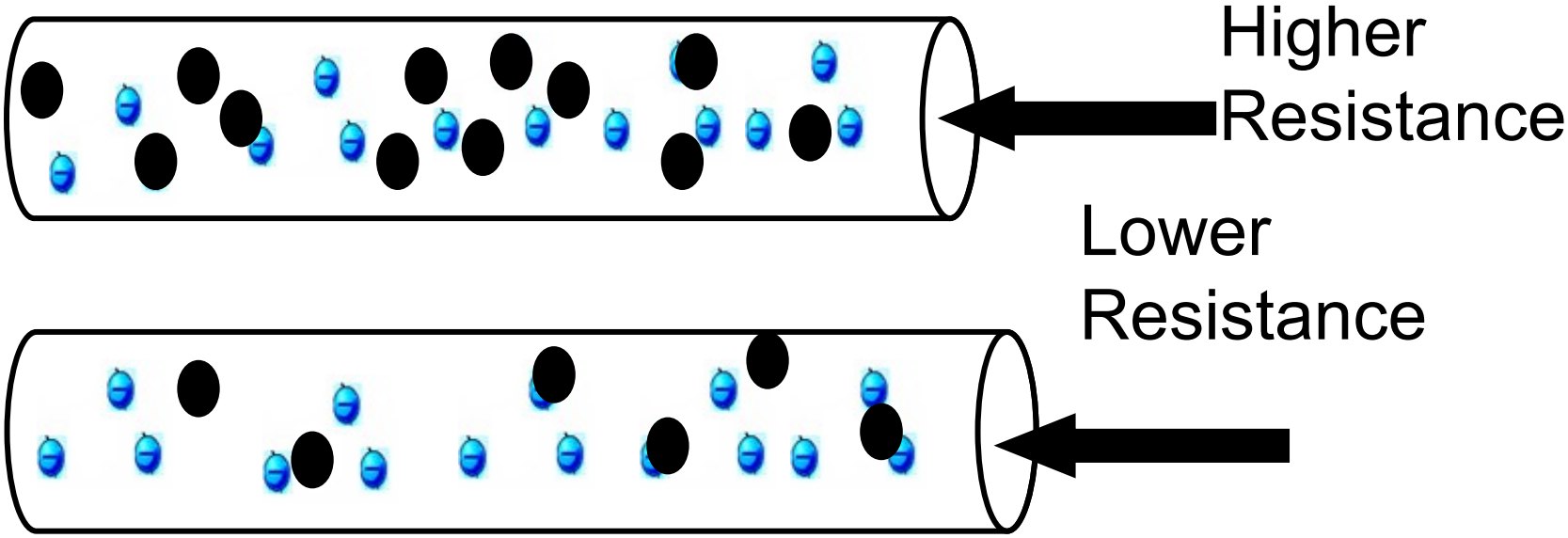
Intensity is the amount of charges that goes through a conductor per time unit. It is measured in Ampere





6.3 Electric magnitude. Resistance

Electric resistance is the opposition to the movement of the charges through a conductor. It is measured in Ohms Ω



6.3 Electric magnitude. Resistance

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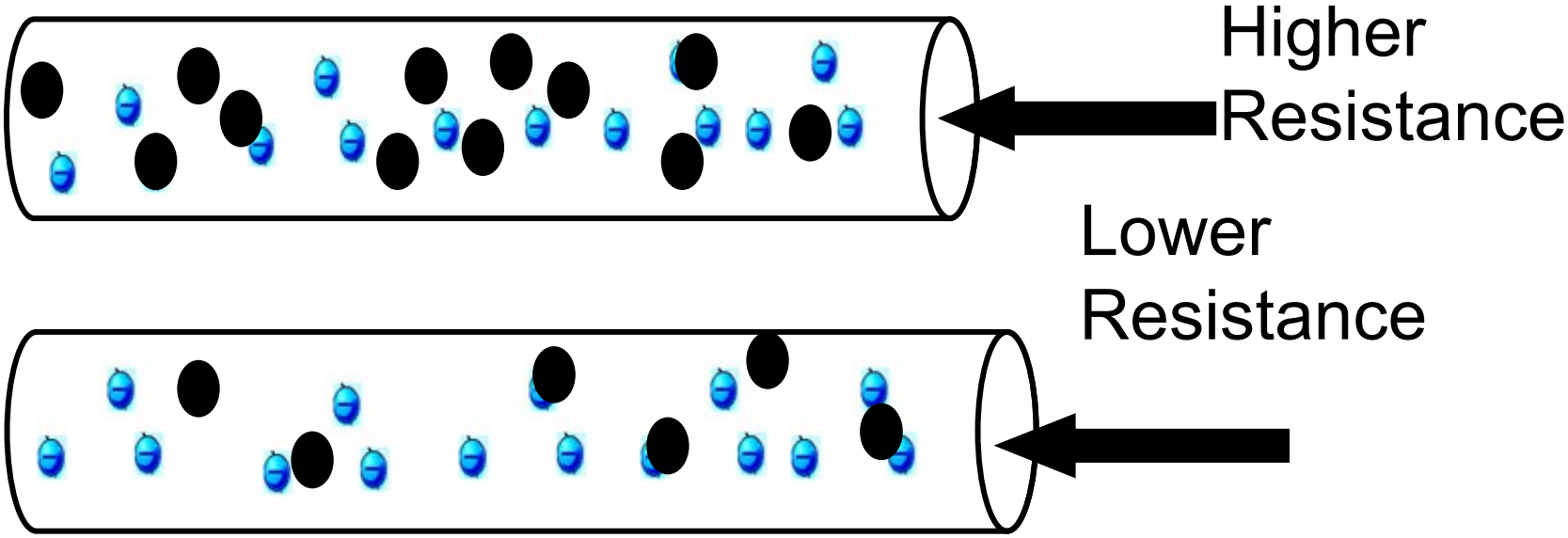


6.4 Ohm's law

Ohm's law links the three electric magnitudes as is shown:

$$I = \frac{V}{R}$$

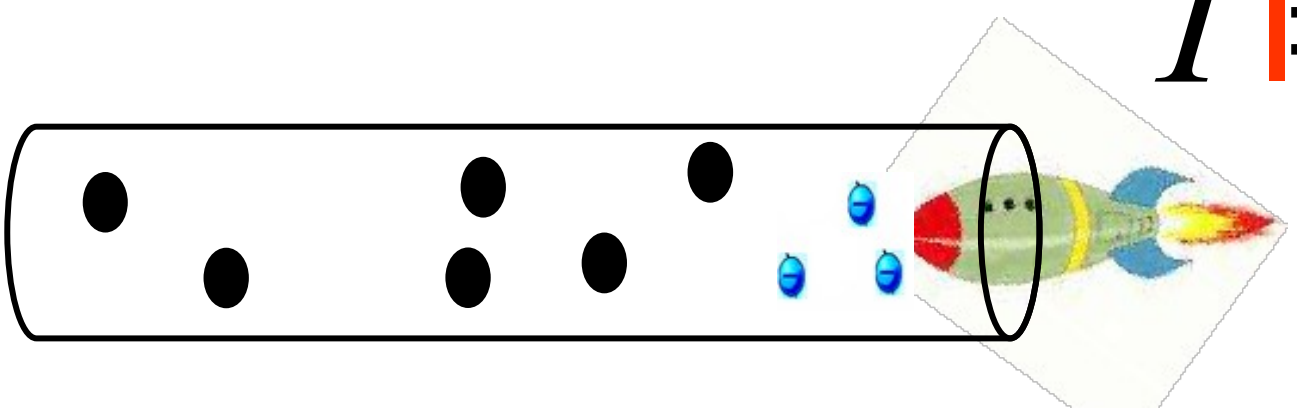
V= Voltage (volt V)
I= Intensity (ampere A)
R= Resistance (ohm Ω)

6.4 Ohm's law

Intensity is **<u>directly proportional to voltage</u>**:

If the **voltage is high** the charges will have a lot of energy, therefore the **Intensity will be high** too

$$I \uparrow = \frac{V}{R} \uparrow$$



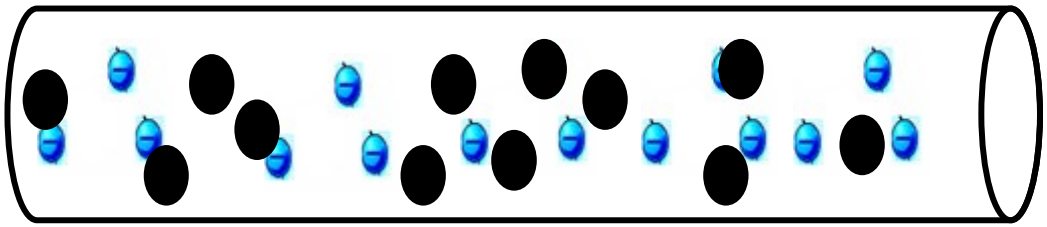
6.4 Ohm's law

Intensity is inversely proportional to Resistance

If there is a **high Resistance** there will be a **low intensity**

$$I \downarrow = \frac{V}{R \uparrow}$$

the charges will cross the material slowly



6.4 Ohm's law
Calculations with Ohm's law

<u>Exercise 3</u>:

Justify how the Intensity will be if:

- We have a low voltage V ↓
- We have a low Resistance R ↓

$$I = \frac{V\downarrow}{R} \qquad I = \frac{V}{R\downarrow}$$

6.3 Electric magnitude. Resistance

<u>4º Exercise</u>: Explain how the Intensity will change if:

- We increase the Resistance and the Voltage
- We decrease the Resistance and we increase de Voltage
- We decrease the Resistance and the Voltage
- We decrease the Resistance and the

6.4 Ohm's law
Calculations with Ohm's law

In order to calculate the value of any electric magnitude, we need to know the value of the other two, and use Ohm's formula:

$$I = \frac{V}{R}$$

For example, if we want to know the value of I and we know that R=20Ω V= 80V:

$$I = \frac{80}{20} = 4$$

$$I = 4A$$

Solution

6.4 Ohm's law

Calculations with Ohm's law

5° Exercise:

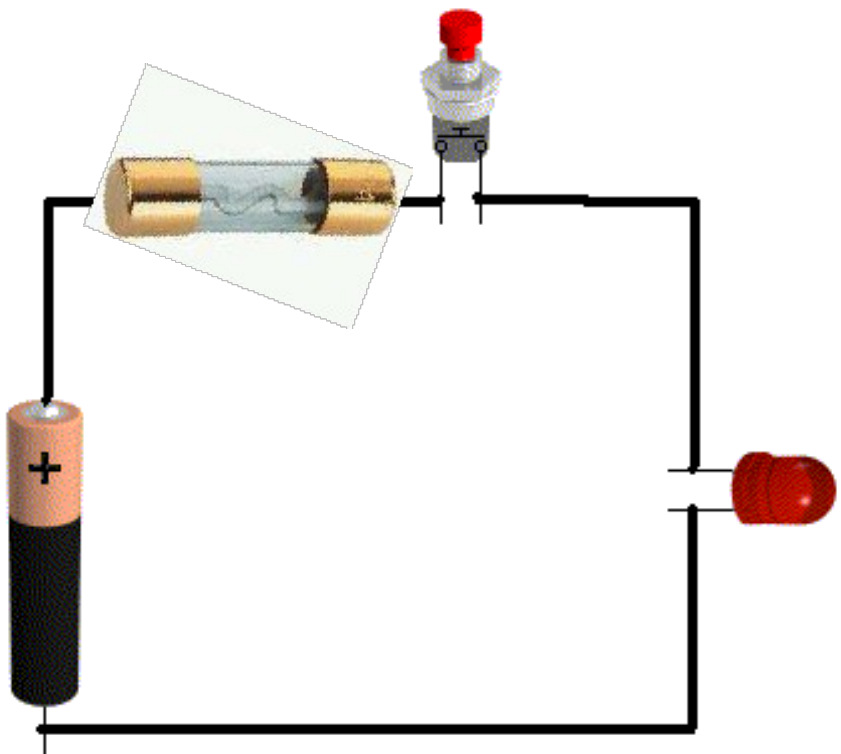
Calculate the value of the circuit magnitudes in these cases:

$$I = \frac{V}{R}$$

V (v)	R (Ω)	I (A)
2	2	
2	4	
	2	4
10		5
5	10	
	20	1000

6.5 Electric circuit

An electric circuit is a group of elements that allows us to control electric current through a



We need:

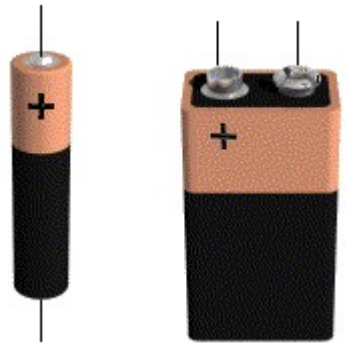
2. Generator
3. Control element
4. Receptors
5. Conductor
6. Protection elements

6.5 Electric circuit. Elements

<u>The essential elements in a circuit are:</u>

<u>1.- Generator</u>: it creates an electric current supplying voltage to the circuit. They can be:

- **<u>Batteries</u>**: they supply electric current but only for a short time.
- **<u>Power supplies</u>**: they give a constant and continuous 'ent.



6.5 Electric circuit. Elements

<u>The essential elements in a circuit are:</u>

<u>2.- Control elements</u>: we can manipulate the electricity through the circuit.

- <u>Switch</u>: 
- <u>Push button</u>: 
- 
- Diverter switch

6.5 Electric circuit. Elements

<u>The essential elements in a circuit are:</u>

<u>2.- Control elements</u>: we can manipulate the electricity through the circuit.

- <u>Switch</u>: It keeps the ON or OFF positions.

For example th tch lights at the bathroom

- <u>Push button</u>:

- <u>Diverter switch</u>:

6.5 Electric circuit. Elements

<u>The essential elements in a circuit are:</u>

<u>2.- Control elements</u>: we can manipulate the electricity through the circuit.

- <u>Switch</u>: 
- <u>Push button</u>: The On position only works while you are pressing the button. For example the door bell 
- <u>Diverter switch</u> 

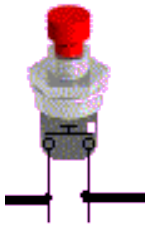
6.5 Electric circuit. Elements

<u>The essential elements in a circuit are:</u>

<u>2.- Control elements</u>: we can manipulate the electricity through the circuit.

- <u>Switch</u>:

- <u>Push button</u>:



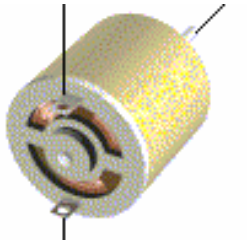
- <u>Diverter switch</u>: it is used to switch a light on or off from different points in the same room, as you have in your bedroom

6.5 Electric circuit. Elements

3.- Receptors: they are the elements that transform the electric energy into other ones that are more interesting for us.

For example

- Incandescent lights:



- Engine:

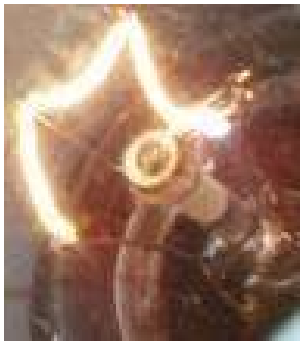
- Resistance:

6.5 Electric circuit. Elements

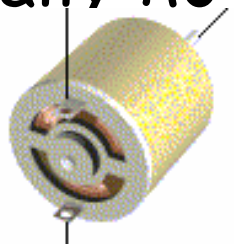
3.- Receptors:

For example

- Incandescent lights: when the electric current goes through the lamp filament it gets really hot and starts emitting light.



- Engine:



- Resistance:

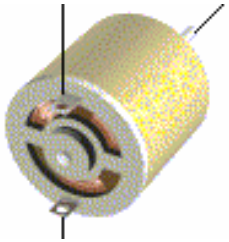
6.5 Electric circuit. Elements

3.- Receptors:

For example

- Incandescent lights:

- Engine: the electricity creates a magnetic field that moves the metal elements of the engine



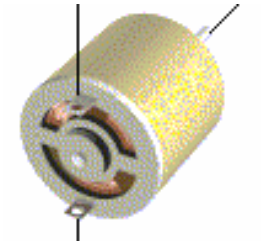
- Resistance:

6.5 Electric circuit. Elements

3.- Receptors:

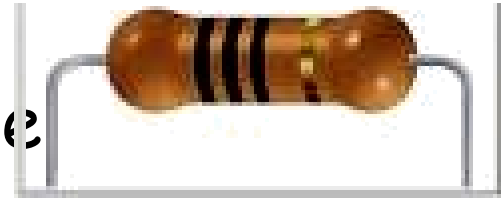
For example

- Incandescent lights:



- Engine:

- Resistance: we use it to decrease the



6.5 Electric circuit. Elements

<u>4º Conductor</u>: all the elements have to be connected to a material that transmits the electric charges.

6.5 Electric circuit. Elements

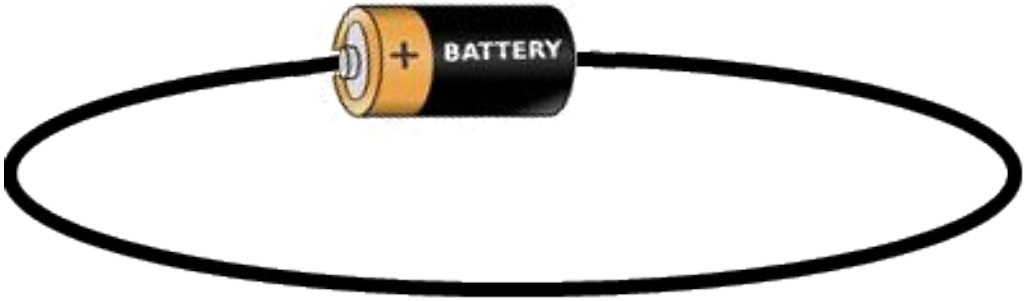
4° Conductor:

Conductors and devices have to be insulated to protect us from discharges that can hurt us

6.5 Electric circuit. Elements

4° Conductor:

The circuit has to be CLOSED in order to allow the electricity to circulate around it from the positive to the negative pole.



6.5 Electric circuit. Elements

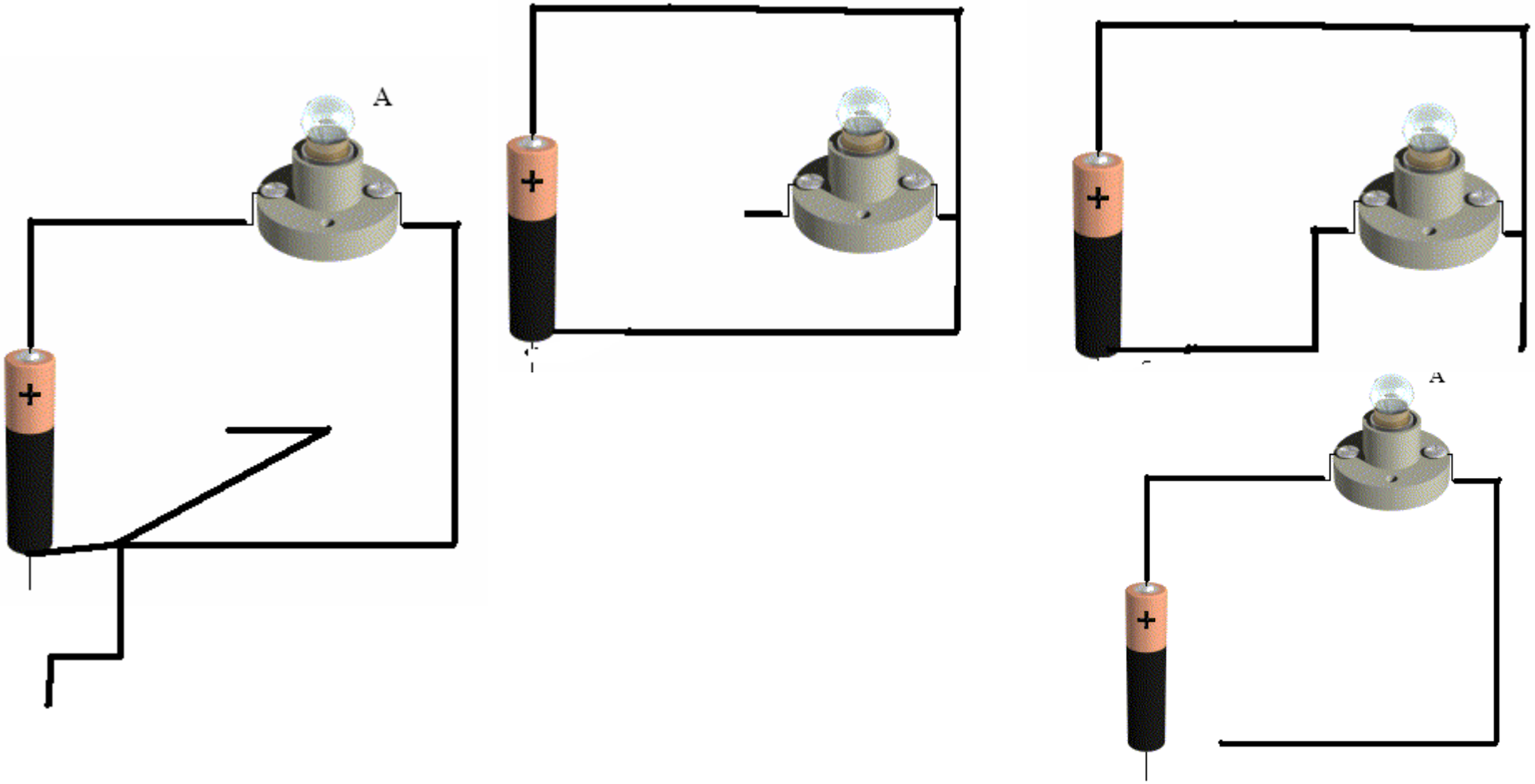
<u>6º Exercise</u>:

- Name and draw 10 electric receptors like a bulb lamp, engine…
- Make a table with 10 insulating and 10 conductive material

6.5 Electric circuit. Elements

- **Exercise 3**

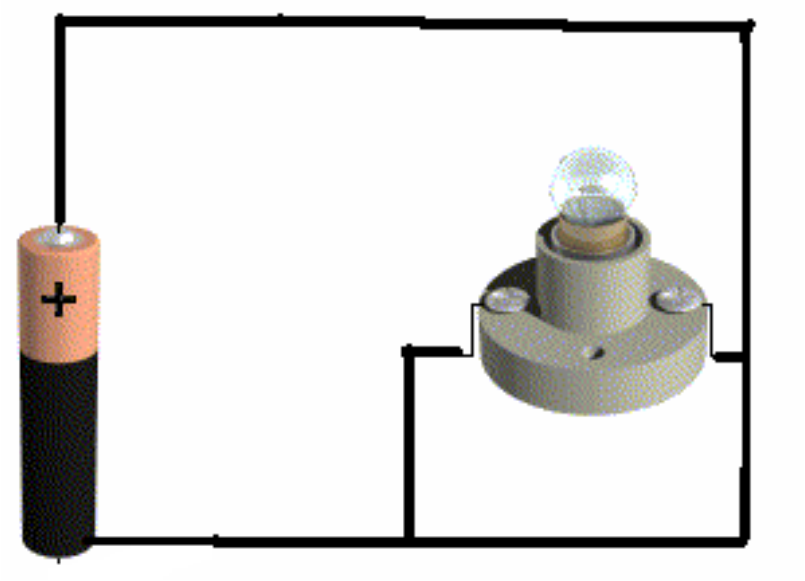
Which one of these lamps will give light?



6.5 Electric circuit. Elements

- **<u>Exercise 4</u>**

Will this lamp turn on?



Solution

6.5 Electric circuit. Elements

5.- Protection elements: they keep all the circuit elements safe from high voltage rises, that can destroy the receptors

- **Fuse**:

- **Circuit breaker**:

6.5 Electric circuit. Elements

5.- Protection elements:

- **Fuse**: the first one will blow, cutting the circuit, in case of a voltage rise. They are easily replaced

- **Circuit breaker**:

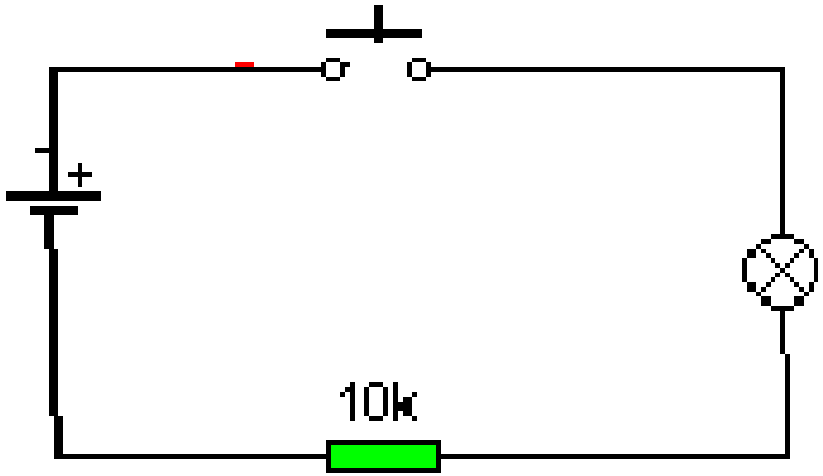
6.5 Electric circuit. Elements

5.- Protection elements:

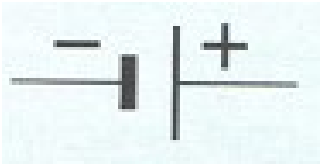
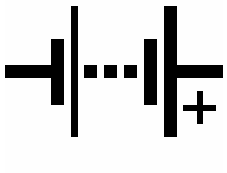
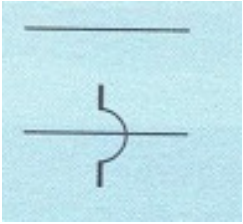
- Fuse:
- Circuit breaker: they are used in new electric installations, at home or in factories. If there is a voltage rise, you don't have to replace them, only reload.

6.5 Electric circuit. Symbols

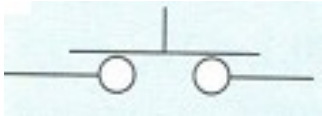
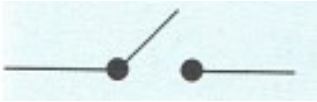
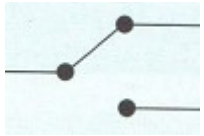
- Electric symbols are used to represent electric circuits with drawings that replace the real circuit elements.



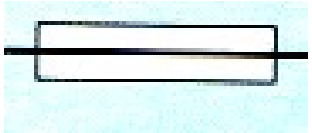
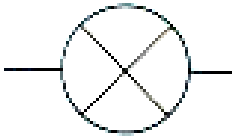
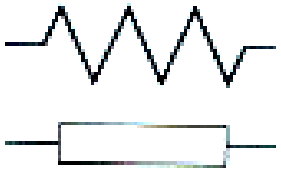
6.5 Electric circuit. Symbols

Generator	
	Battery
	Battery association
Conductors:	
	When two conductors are crossed without any contact we indicate it with a curve

6.5 Electric circuit. Symbols

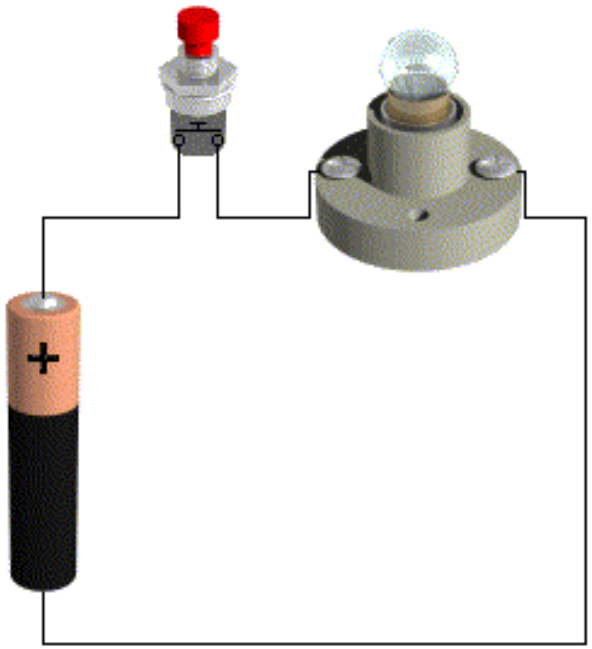
Control elements	
	Push button
	Switch
	Diverter switch

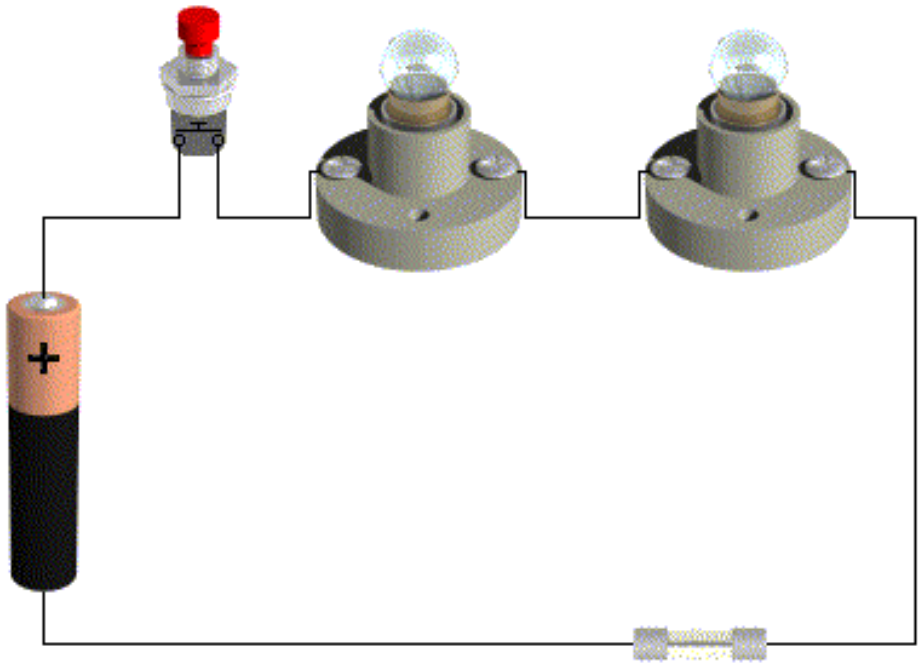
6.5 Electric circuit. Symbols

Protection elements	
	Fuse
Receptors:	
	Lamp
	Resistances: they have two symbols
	Engines

6.5 Electric circuit. Symbols

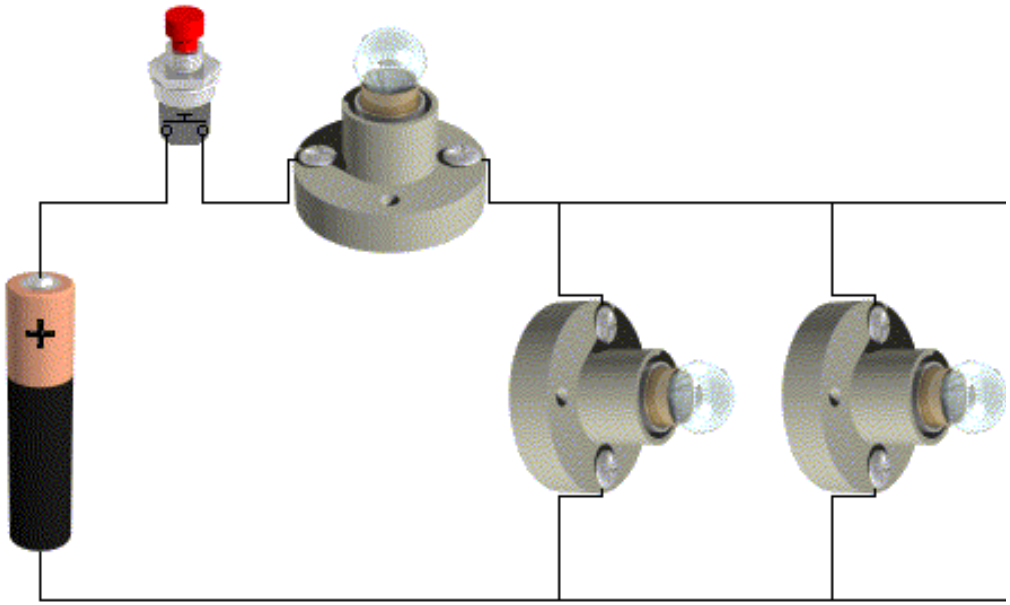
7º Exercise: Draw the following circuit using electric symbols

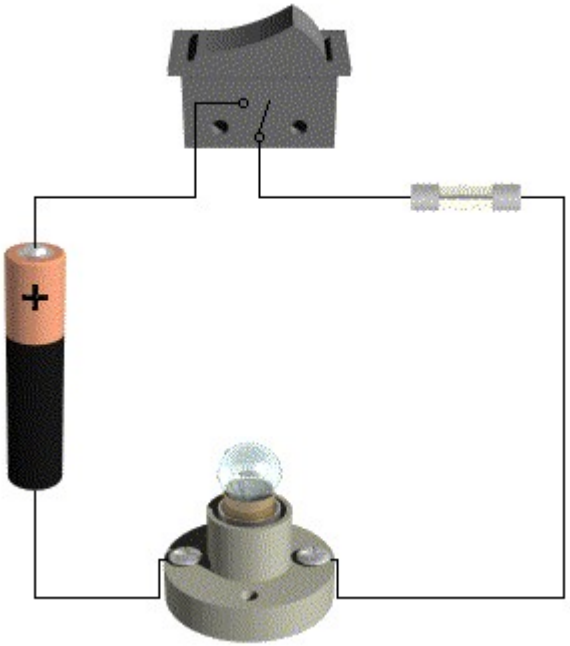




6.5 Electric circuit. Symbols

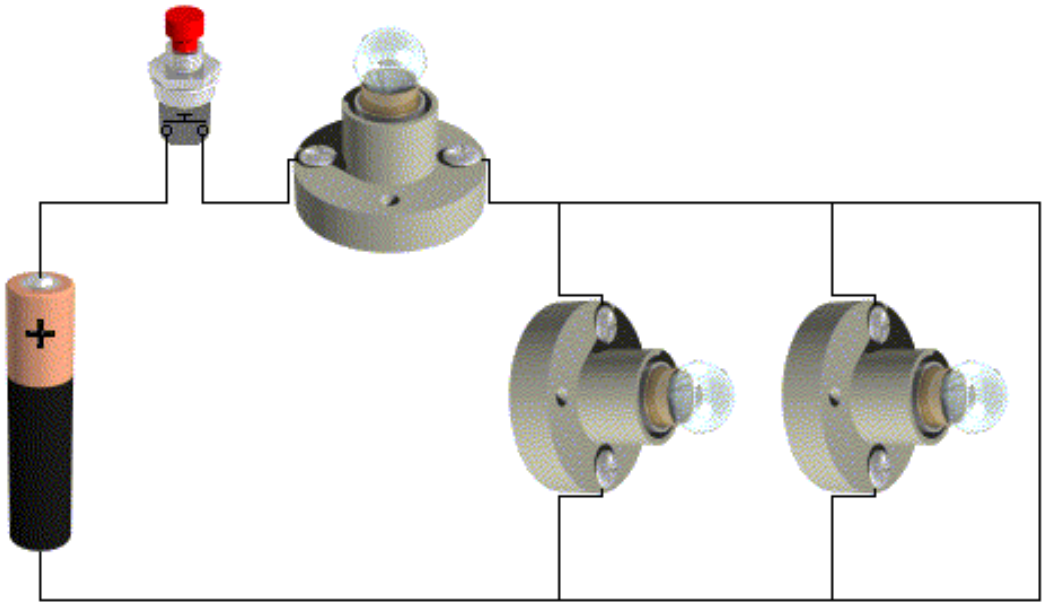
8º Exercise: Draw the following circuit using electric symbols

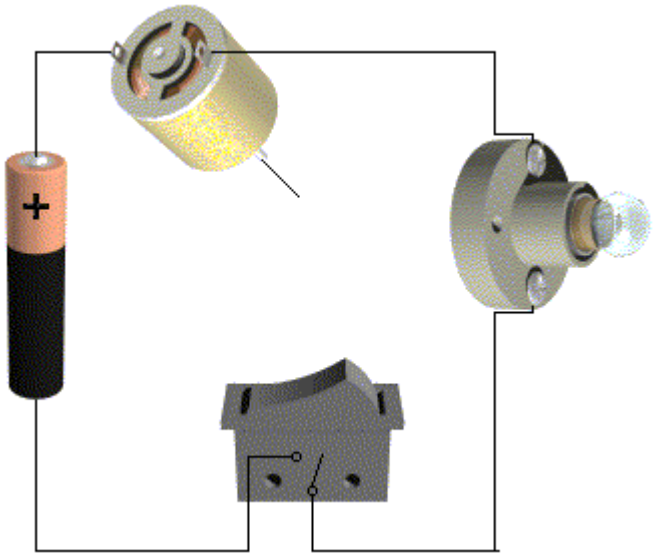




6.5 Electric circuit. Symbols

9º Exercise: Draw the following circuit using electric symbols





6.6 Electric associations

The behaviour of electric elements depends on how they connect to each other.

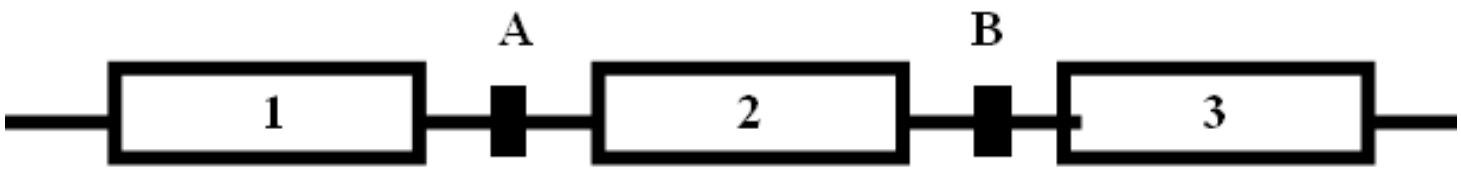
There are three possible configurations :

3. Series
4. Parallel
5. Mixed

6.6 Electric circuits

SERIES circuit

The series circuit connects the electric elements one behind the other



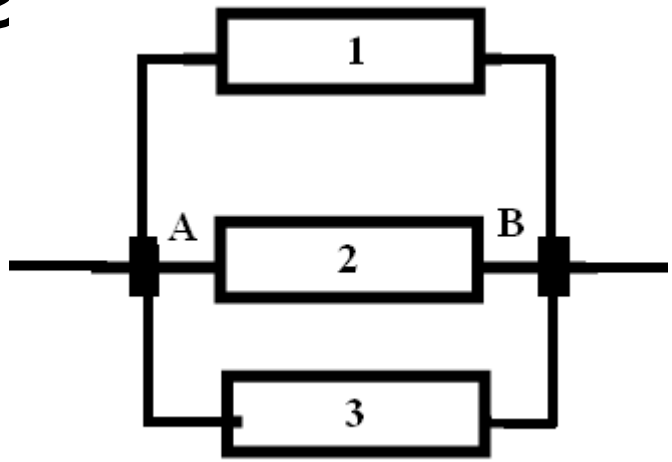
In this way, there is only one connection point between elements

- 1 & 2 are connected only by A

6.6 Electric associations

PARALLEL association

In this association, all the elements are connecte

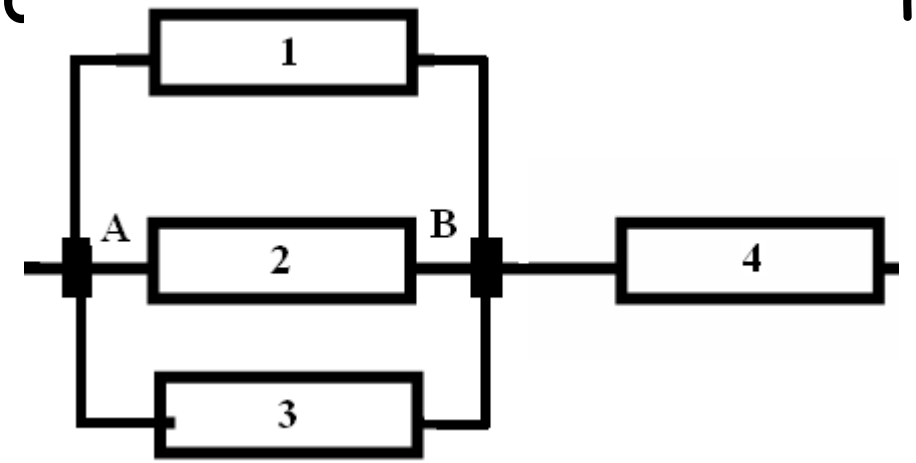


So, 1, 2 & 3 are connected by A and B

6.6 Electric associations

MIXED association

A mixed association has elements associated in parallel and in series



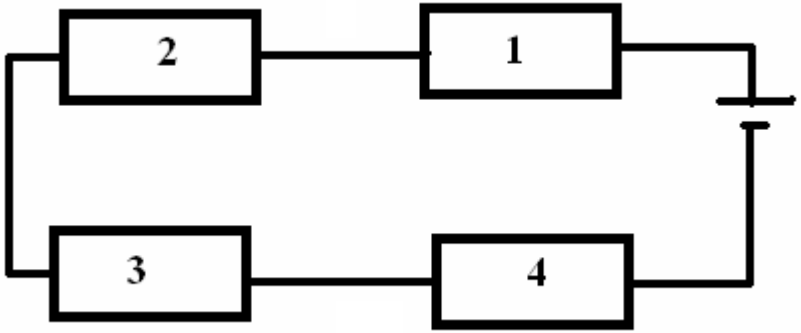
1, 2 & 3 are in parallel and all of them are in series with 4

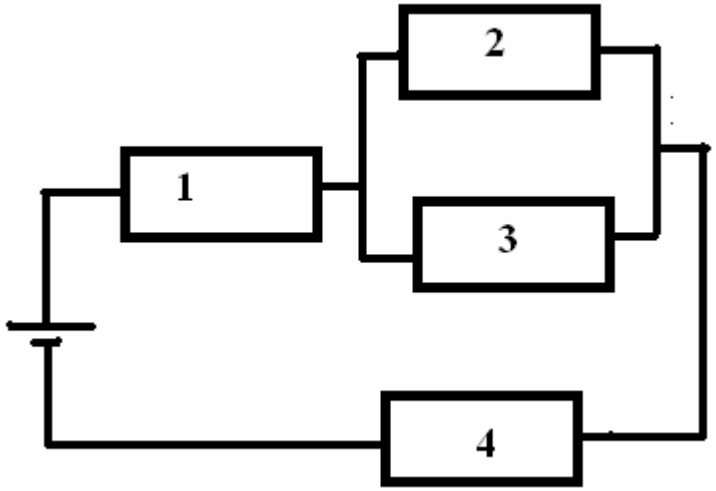
6.6 Electric associations

Solution

10° Exercise

Which of these elements are associated with series, parallel or mixed circuits? Name the connection points with letters



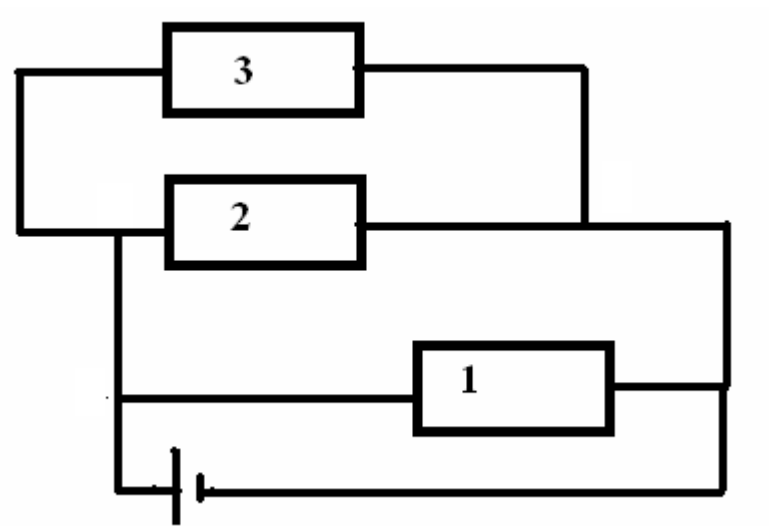


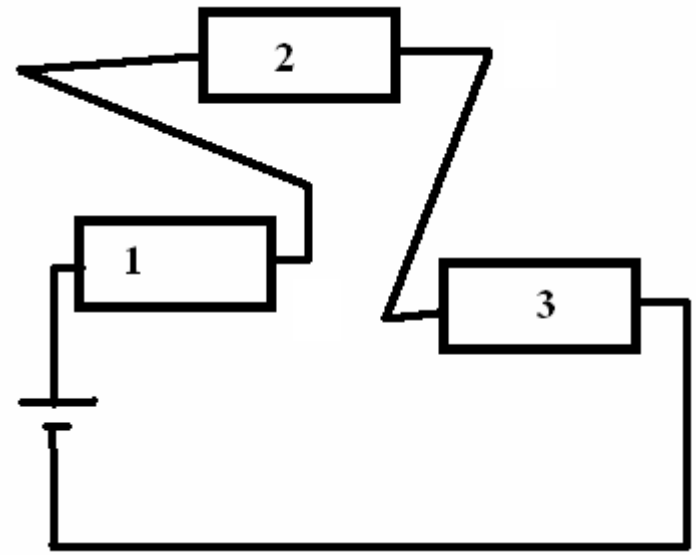
6.6 Electric associations

Solution

11° Exercise:

Which of these elements are associated with series, parallel or mixed circuits. Name the connection points with letters



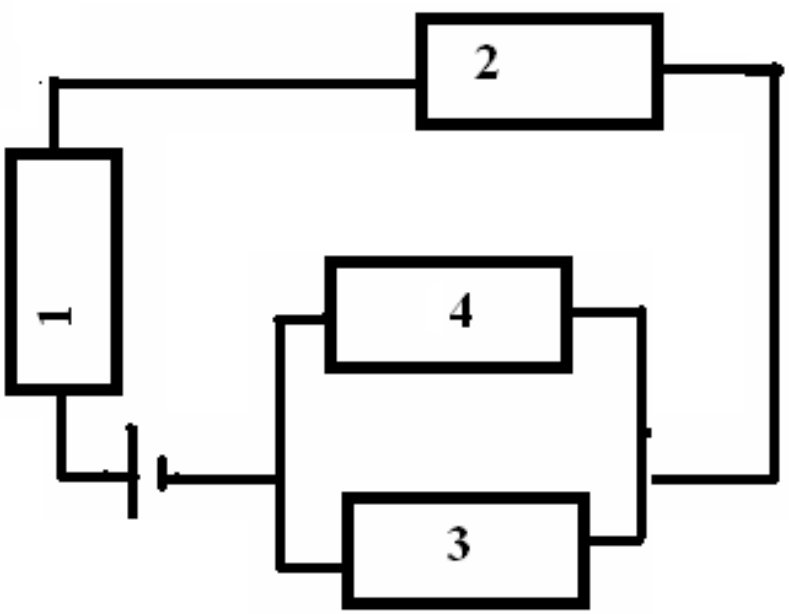


6.6 Electric associations

Solution

12° Exercise

Which of these elements are associated with series, parallel or mixed circuits. Name the connection points with letters



6.6 Electric associations

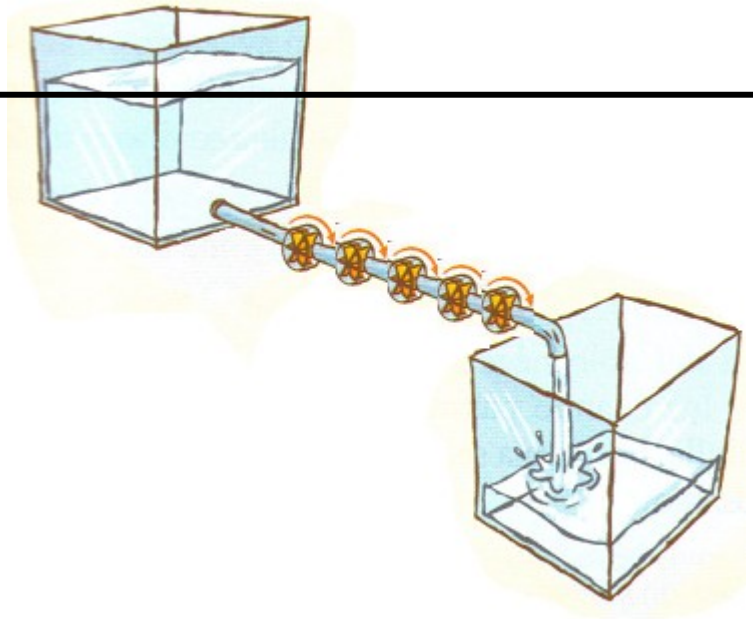
But what happens to receptors when they are connected in series or parallel associations?

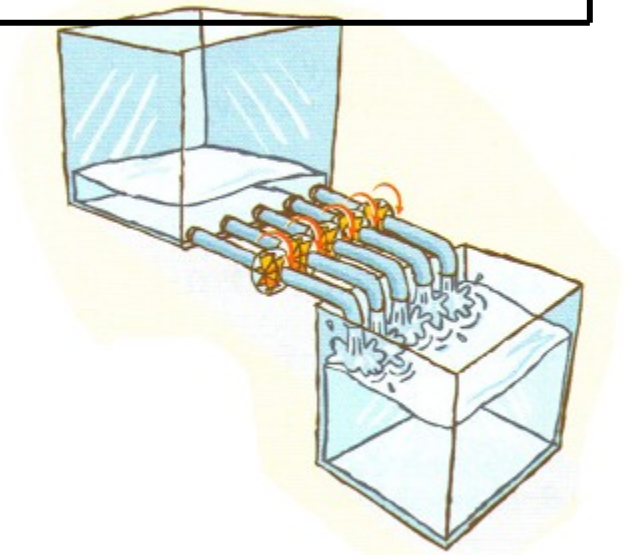
Series and parallel associations change the value of intensity and voltage thr s

6.6 Electric associations

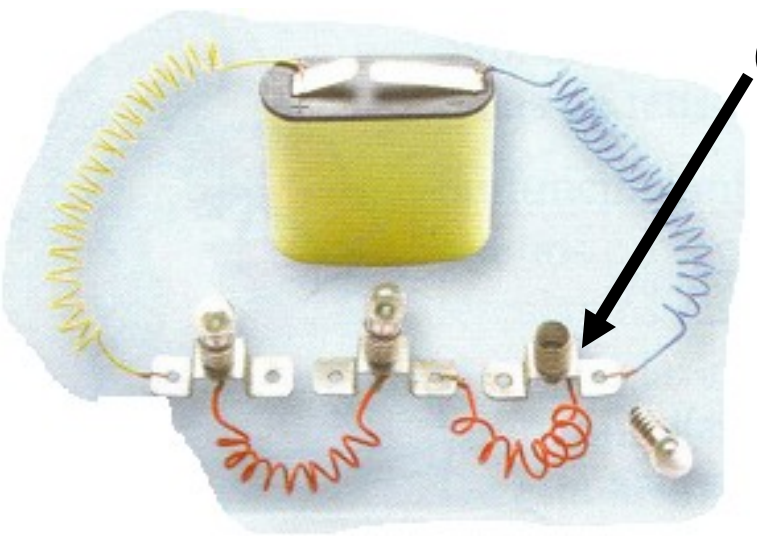
Voltage	
Series	Parallel
Voltage is distributed between elements, that is the reason why they have less energy for each lamp, so the light is lower.	Voltage is the same in all elements, so all the lamps have the same energy and the light is higher.

Intensity	
Series	Parallel
All the lamps are in line, so they create a high resistance, that is the reason why the intensity is lower but the battery will have a longer life.	All lamps are separated so they create a low resistance, that is the reason why the intensity through the lamps is higher, but the battery will have a shorter life

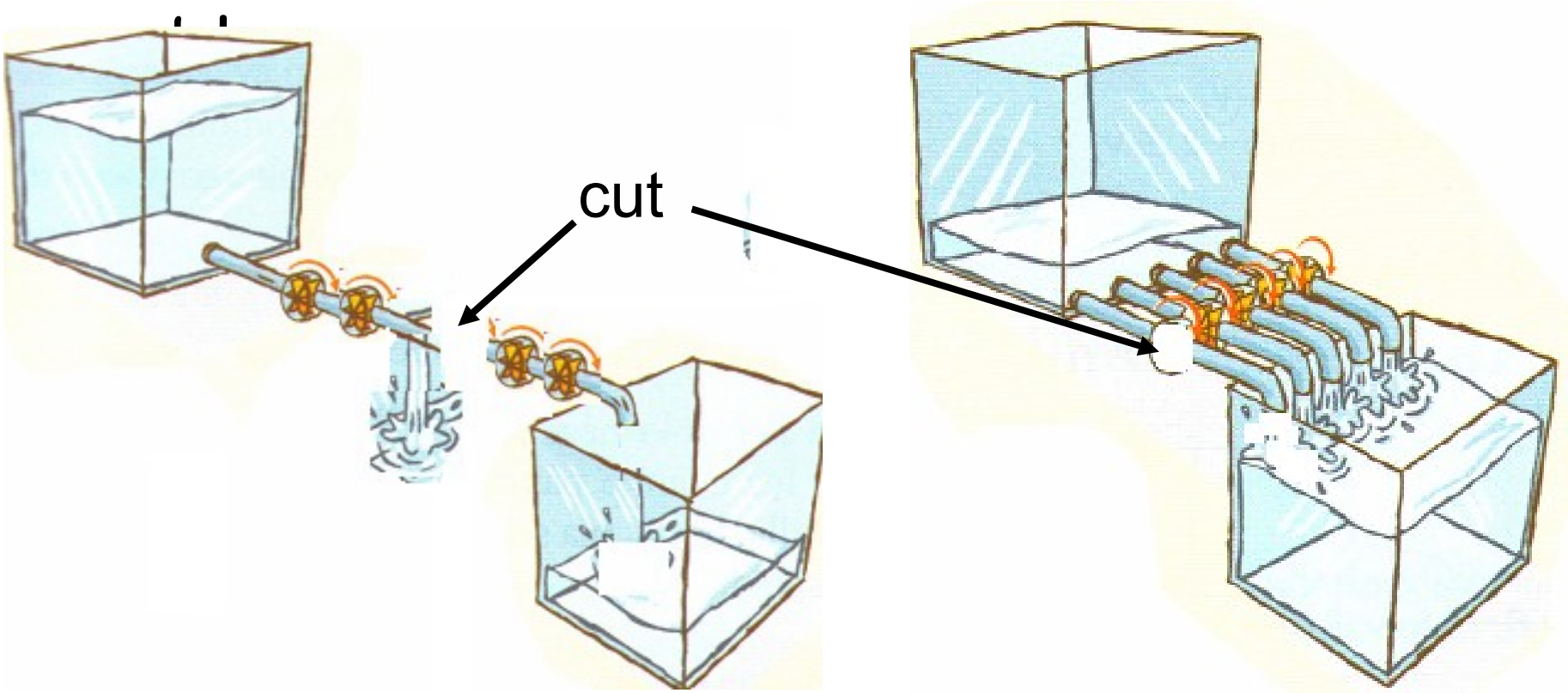




Circuit	
Series	Parallel
If there is any cut along the conductor, the electric current will not be able to go from the positive to the negative pole.	If there is any cut along the conductor, the electric current can go through any other way

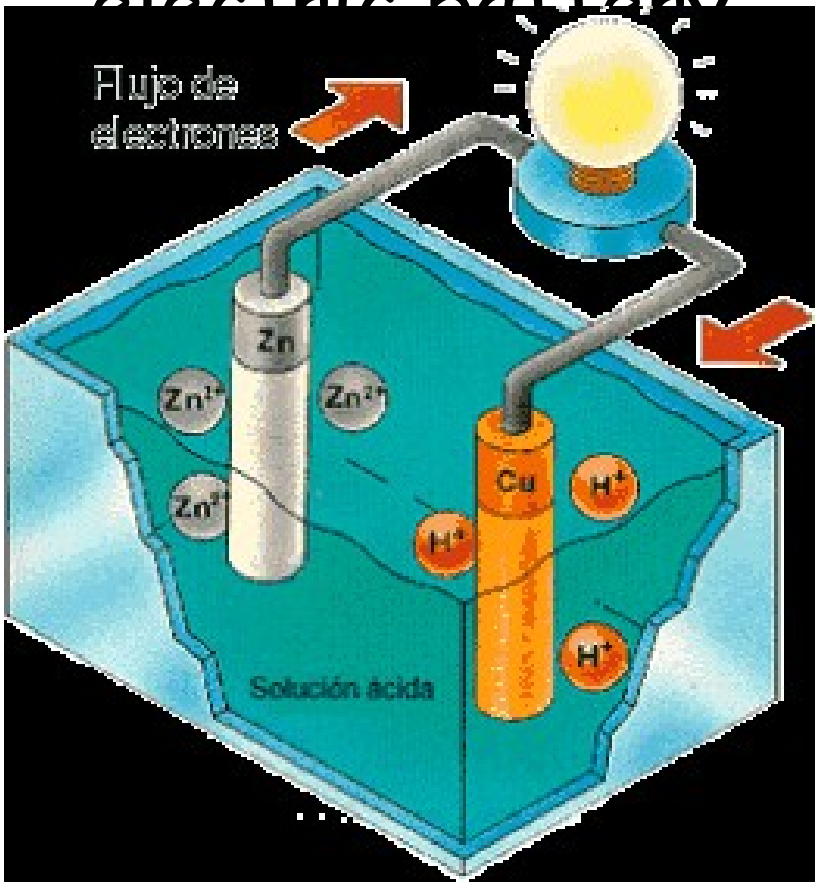


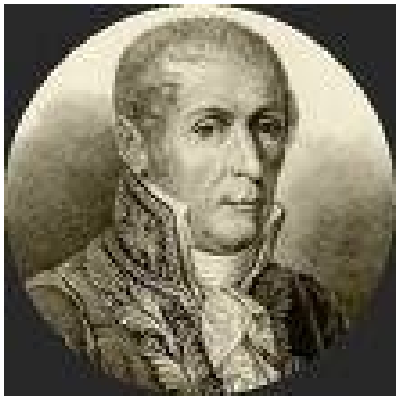
- If there is any cut in series association the water can't go further. But in parallel association there will be no



6.7 Electric energy production

Electricity generation started when Alessandro Volta made the first electric battery

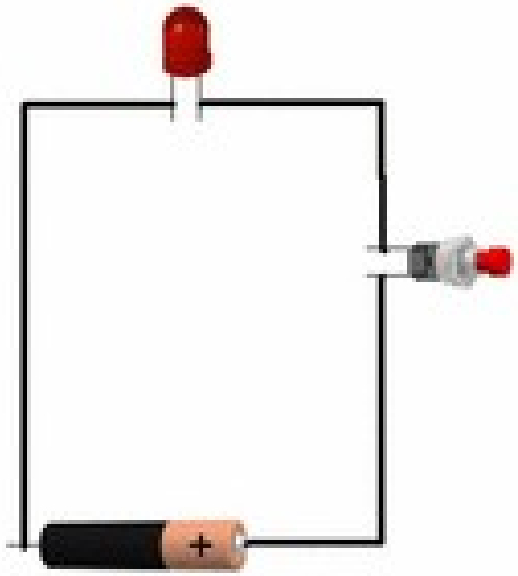




Alessandro Volta (1745-1825)

6.7 Electric energy production

Hans Christian Oersted discovered that a electric current can disturb a compass.



Alessandro Volta
(1777-1851)

The same happens when we put close a magnet, so he concluded that the circuit created an artificial magnet.

6.7 Electric energy production

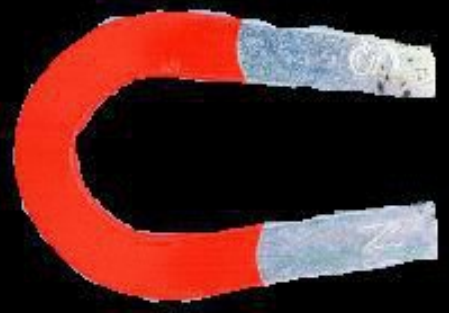
Mr Michael Faraday had an idea, if a electric current can create an artificial magnet

Can a magnet create an artificial electric current?

6.7 Electric energy production

YES!!!!

So Mr Michael Faraday discovered that we can create electricity with a magnet that is moving near a close circuit

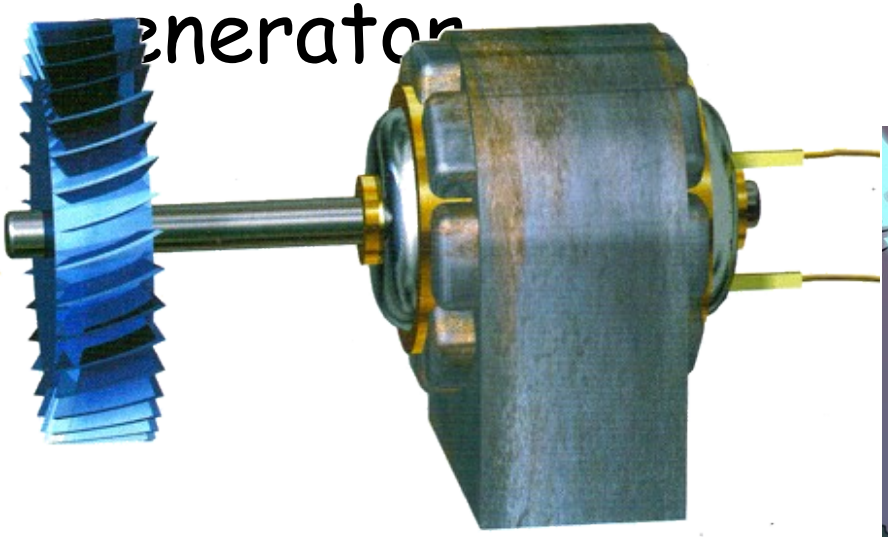


6.7 Electric energy production

Nowadays, industrial power stations use the Faraday's discovery

6.7 Electric energy production

They use others energies to move a turbine that moves a circuit inside the magnet of the generator

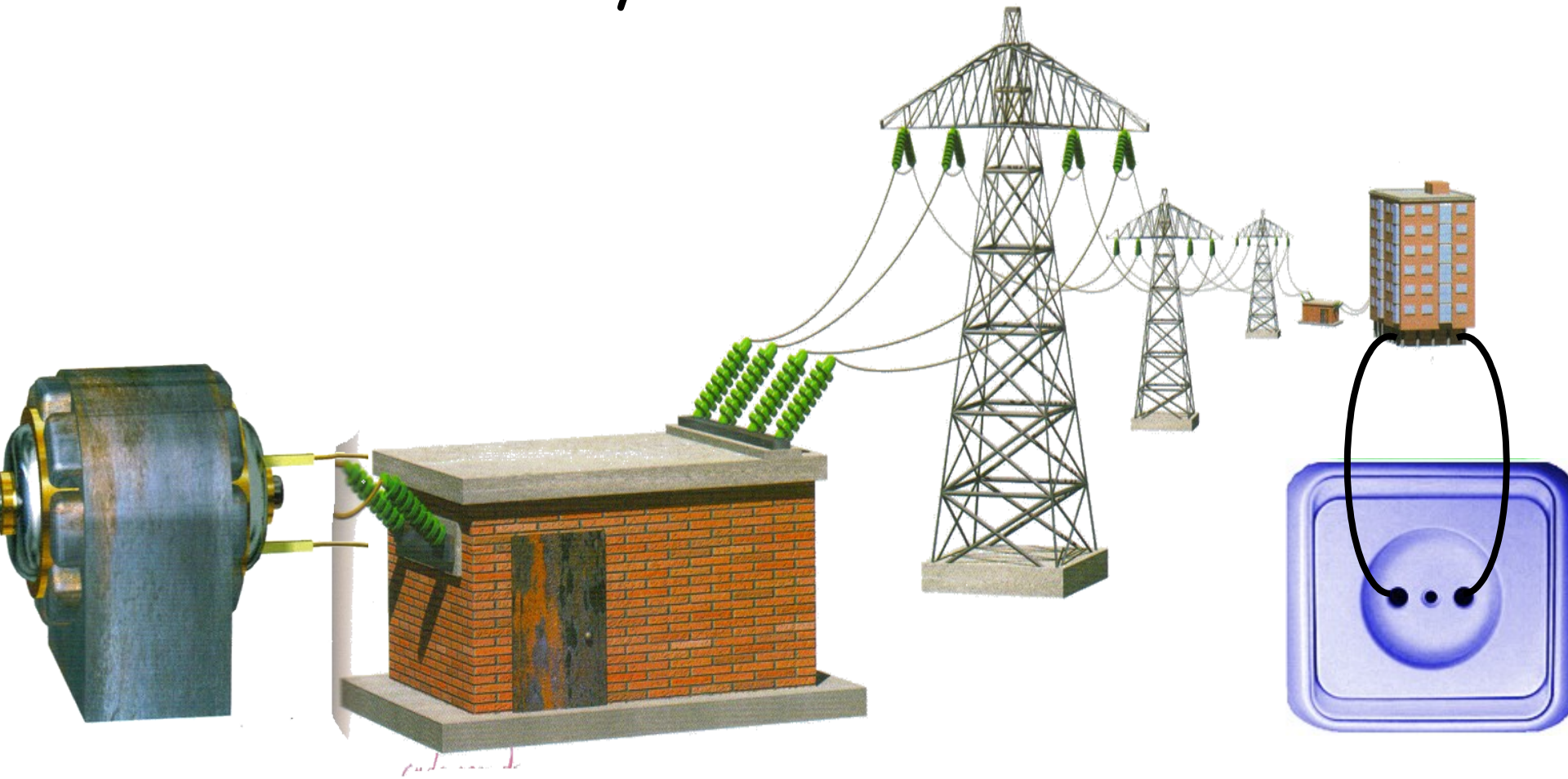


turbine

Generator

6.8 Electric power

From the generator of the Power Station the electricity is transmitted to our homes

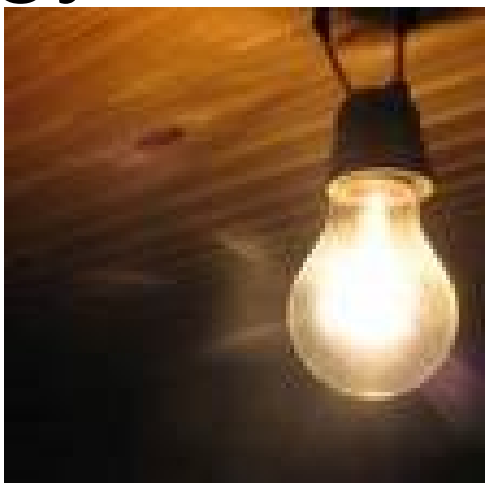


6.8 Electric power

What is the difference between a 100 W and 7 W bulb lamp ?

6.8 Electric power

This is a **energy saving light** because it consumes less energy (7 W) than a incandescent bulb light (100W)



We know it because W is the electric power unit

6.8 Electric power

W is the unit of the Electric Power and it express the **energy consumed per time unit** of an electric device

$$P = V \cdot I$$

P= Power (Watts W)
V= Voltage (volt V)
I= Intensity (ampere A)

6.8 Electric power

At home all plugs have 230 Volts, so if we know the Power of a bulb lamp of 100W we can calculate the Intensity through the lamp.

$$P = 100W$$

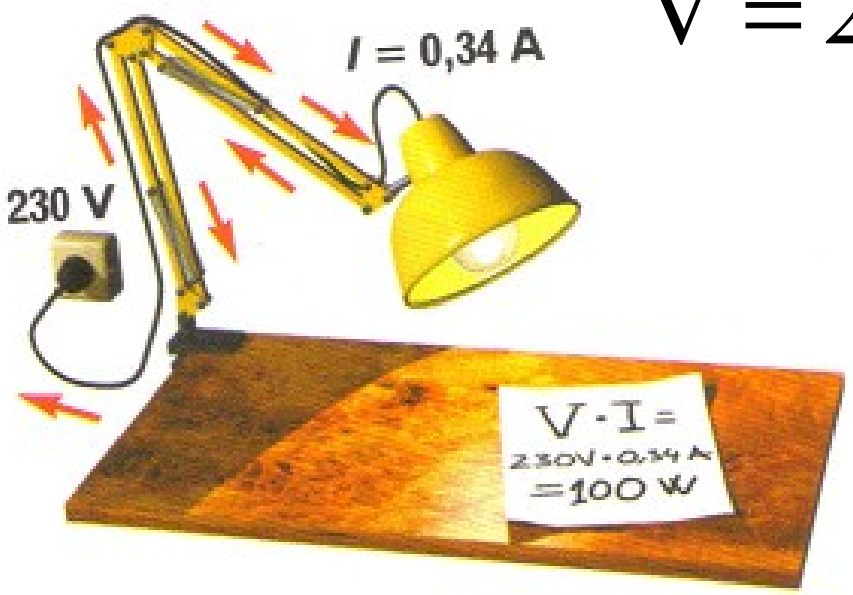
$$V = 230\ V$$

$$P = V \cdot I$$

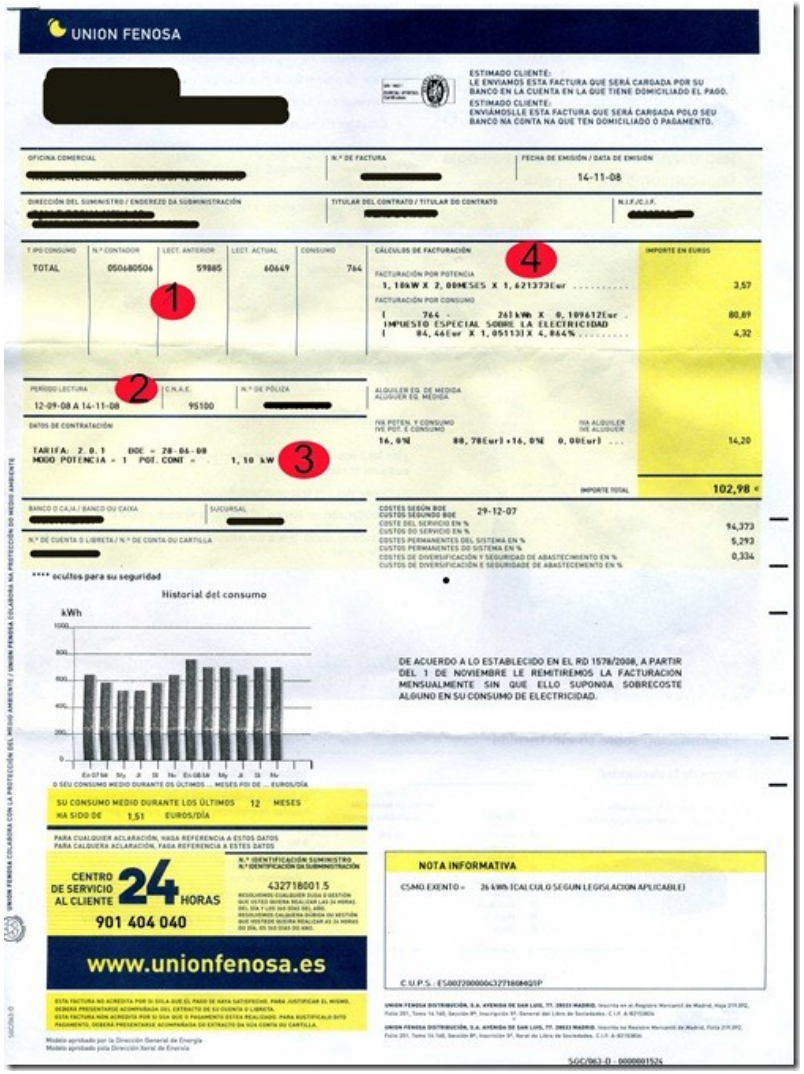
$$I = \frac{P}{V}$$

$$I = \frac{100}{230}$$

$$I = 0{,}34A$$



6.8 Electric power

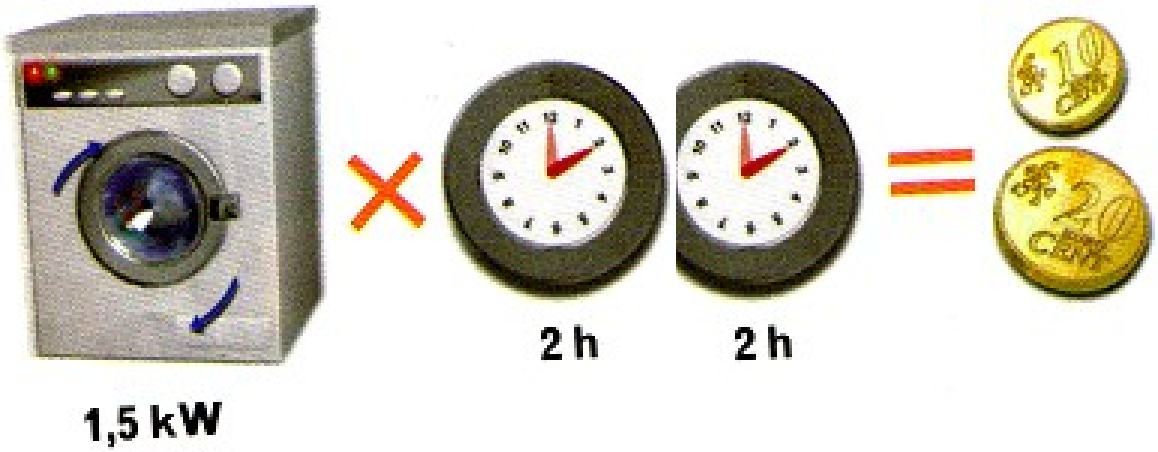


The electricity that we consume is measured in kwh and we pay around 0,1 €/Kwh:

6.8 Electric power

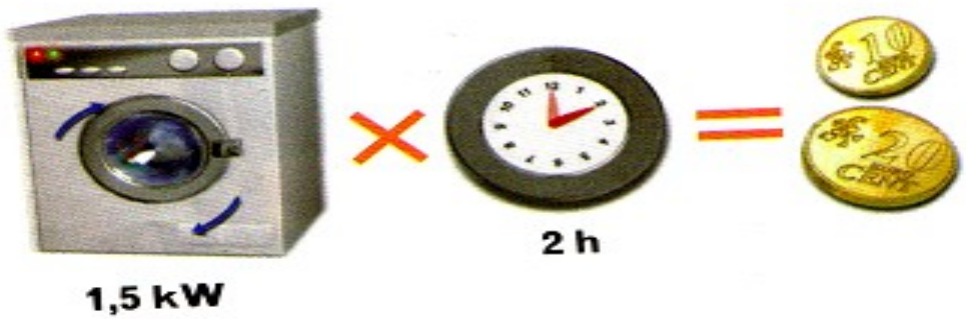
A kwh is the result of multiply the Power and the hours of use:

$$P_{kWh} = P \cdot h$$



6.8 Electric power

In order to know the price that we have to pay we have to multiply the Power in kwh by its pri



$$\text{Price} = P_{kWh} \cdot 0{,}1 = P \cdot h \cdot 0{,}1$$

6.8 Electric power

Let's Calculate how much we have to pay when we use a washing machine for 2h if it consumes 1500W

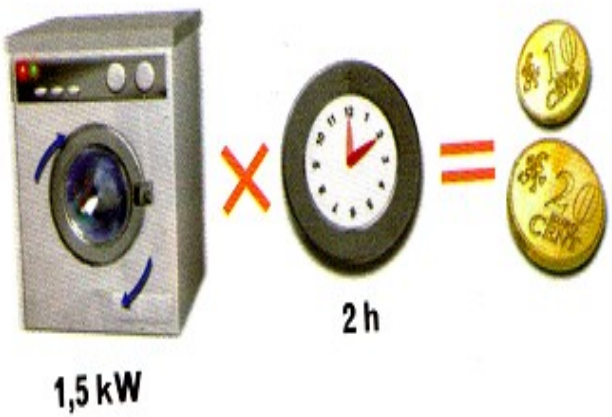
$$P = 1500W = 1{,}5kw$$

$$Time = 2\,h$$

$$P_{kWh} = Ph$$

$$P_{kWh} = 1{,}5 \cdot 2$$

$$P_{kWh} = 3kwh$$



$$Price = P_{kWh} \cdot 0{,}1$$

$$Price = 3\,kwh \times 0{,}1 \frac{€}{kwh}$$

$$Price = 0{,}3€$$

11. ●● Une con flechas.

I •	• Voltaje •	• V
V •	• Intensidad •	• Ω
R •	• Resistencia •	• A

13. ●●● Señala si las siguientes afirmaciones son verdaderas o falsas:

a) La resistencia se mide en amperios.

b) Una bombilla transforma la energía eléctrica solo en energía luminosa.

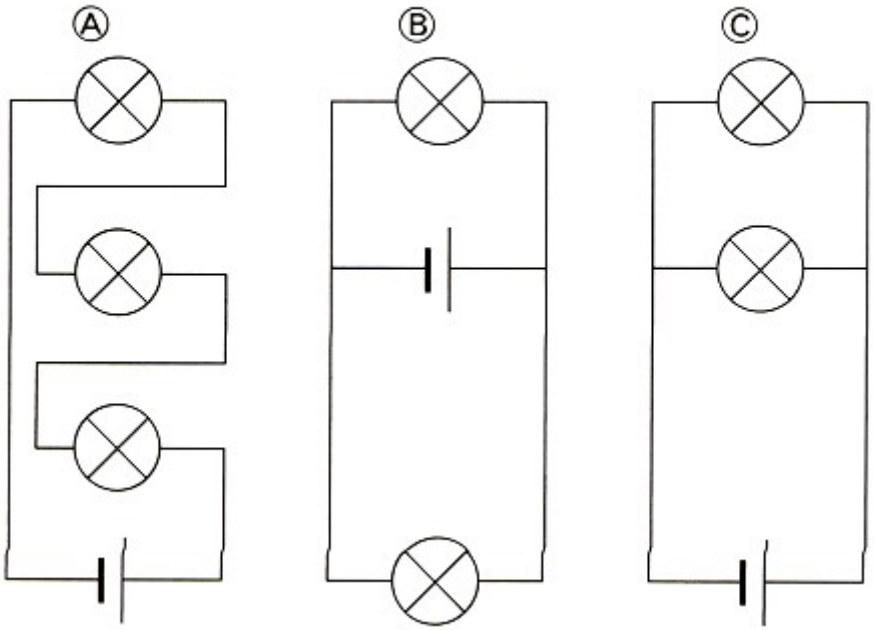
c) Los fusibles protegen a los aparatos si hay una subida de tensión.

d) Una expresión matemática de la ley de Ohm es:

$$I = \frac{V}{R}$$

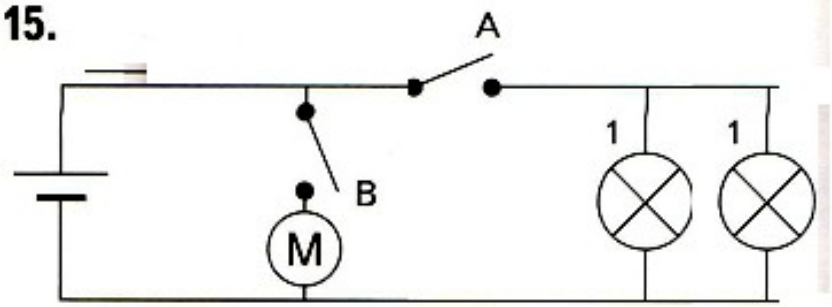
e) Si pongo dos bombillas en paralelo, lucen menos que si las conecto en serie.

14. ● ¿Cuáles de estos montajes están en serie y cuáles en paralelo?



Point out in the table if the engine and lamps works for the following situations

15.



	A closed B open	A open B closed	A closed B closed
Engine			
lamp 1			
lamp 2			

Calculate the value of the intensity in these cases:

V (v)	R (Ω)	I (A)
8	2	
7	2	
4	8	
300	6	
21	7	
1000000	20	

6.4 Ohm's law

Calculations with Ohm's law 5° Exercise Solution

V (v)	R (Ω)	I (A)
2	2	$I = \frac{V}{R} \quad I = \frac{2}{2} \quad I = 1A$
2	4	$I = \frac{V}{R} \quad I = \frac{2}{4} \quad I = 0{,}5A$

6.4 Ohm's law

Calculations with Ohm's law Solution

V (v)	R (Ω)	I (A)
$V = IR$ $V = 4 \cdot 2$ $V = 8V$	2	4
10	$R = \frac{V}{I}$ $R = \frac{10}{5}$ $R = 2\Omega$	5

exercise

6.4 Ohm's law

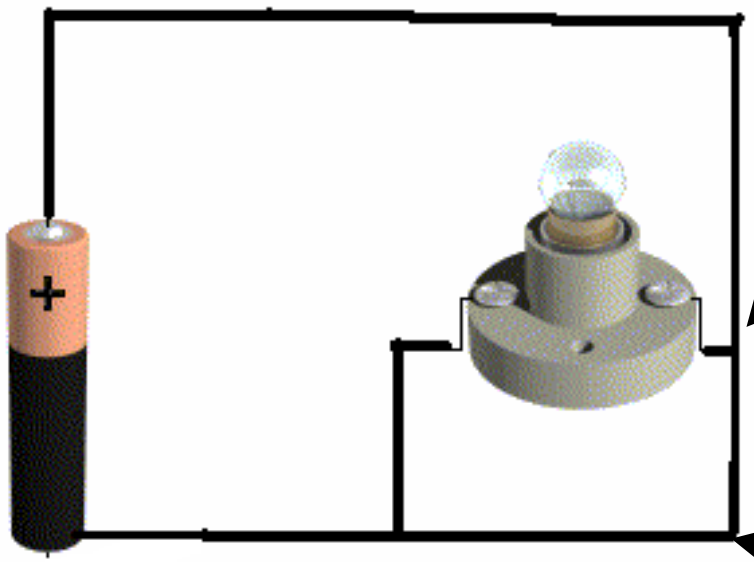
Calculations with Ohm's law Solution

V (v)	R (Ω)	I (A)
5	10	$I = \frac{V}{R}$ $I = \frac{5}{10}$ $I = 0{,}5\ A$
$V = IR$ $V = 1000 \cdot 20$ $V = 20000V$ $V = 20kv$	20	1000

6.5 Electric circuit. Elements

Exercise

The electric current always goes through the route with less resistance, like water



Here we have the resistance needed to create light

No resistance

6.6 Electric associations

Exercise

10° Exercise solution

red-series Blue: parallel

SERIES:

1 and 2 are joined by A.

2 & 3 are joined by B

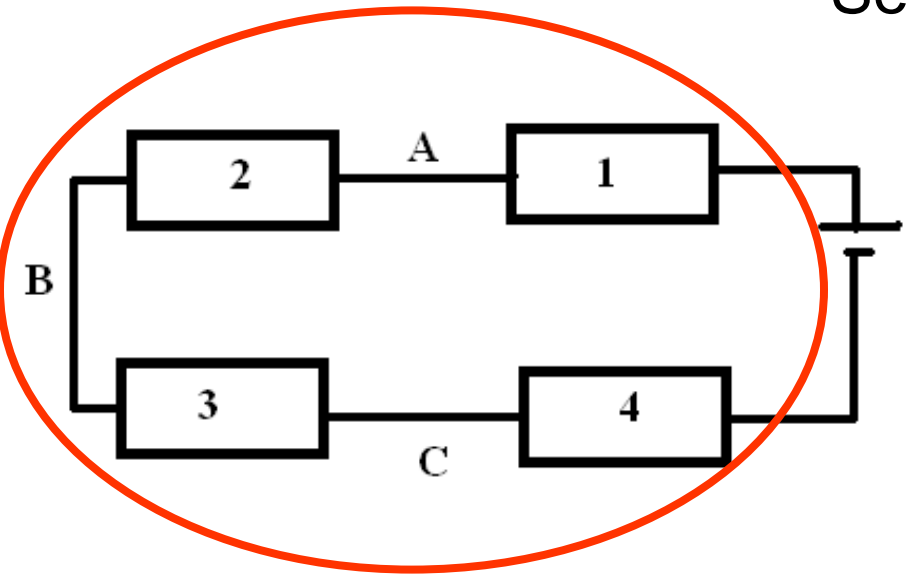
3 & 4 are joined by C

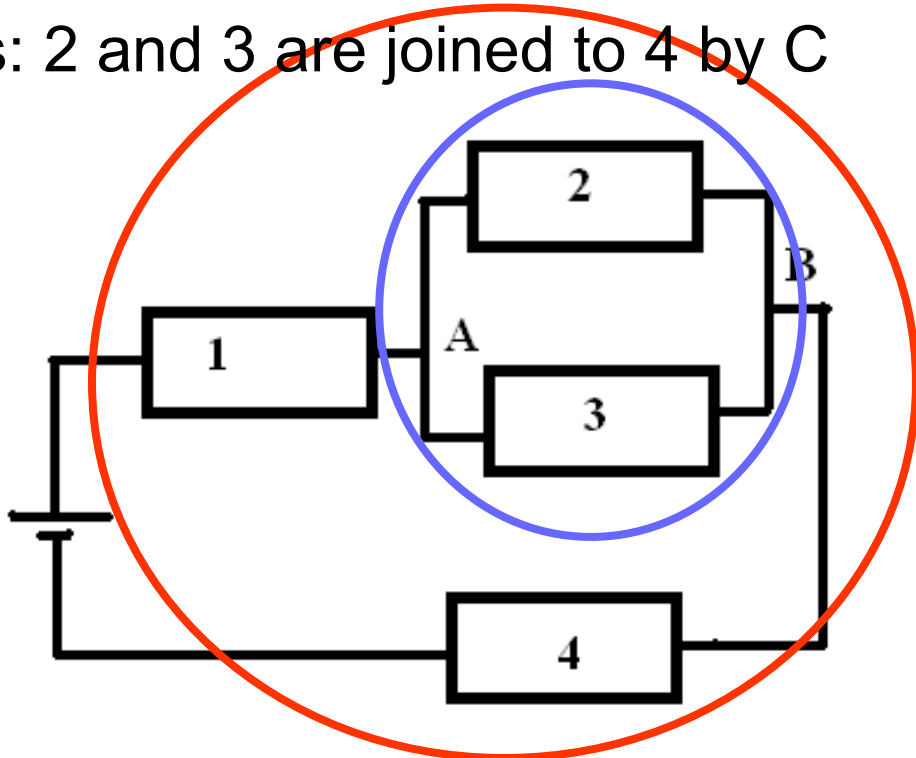
MIXED:

Series:1 is joined to 2 and 3 by A

Parallel: 2 and 3 are joined by A and B

Series: 2 and 3 are joined to 4 by C





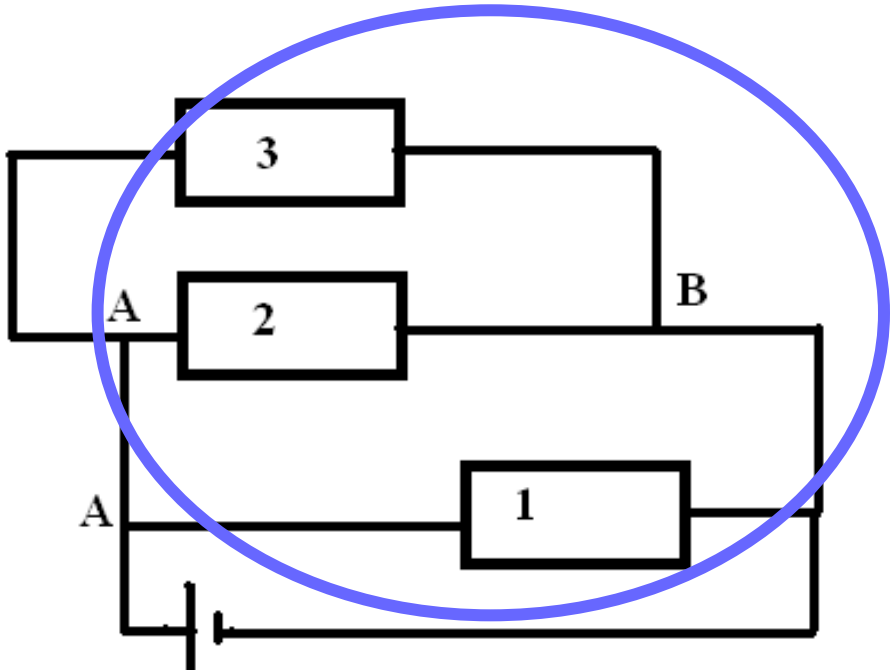
6.6 Electric associations

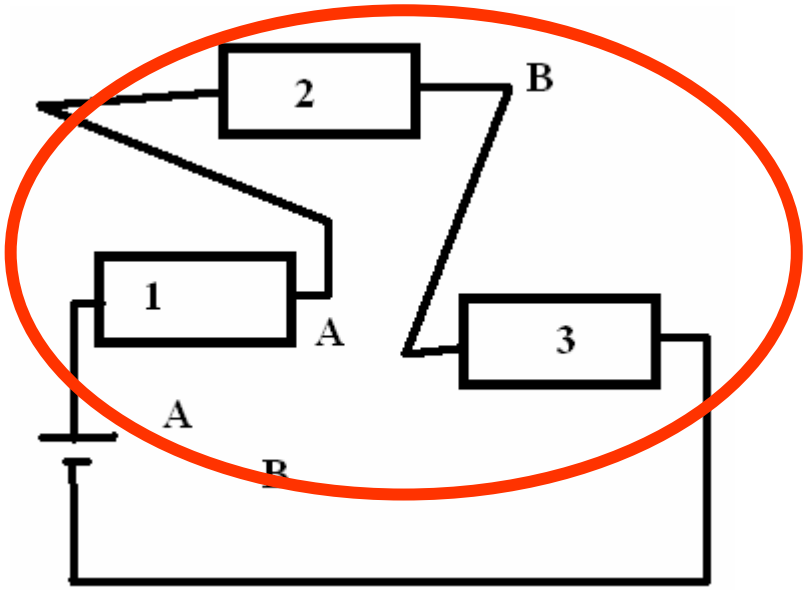
Exercise

11° Exercise solution

Parallel: 1, 2 and 3 are joined together by A and B

Series: 1 and 2 are joined by A; 2 and 3 are joined by B





6.6 Electric associations

Exercise

12° Exercise solution

Mixed:

Series: 1 and 2 are joined to A

Series: 2 and the 4 & 3 association are joined by B

Parallel: 4 and