ELECTRIC CURRENT IN GASES

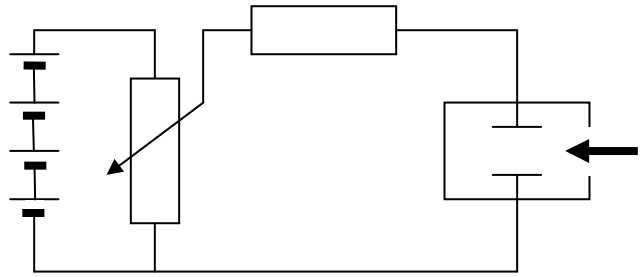
1. Conduction in gases, self-sustaining and initiated gas discharge

Gases can conduct current when containing ions and free electrons.

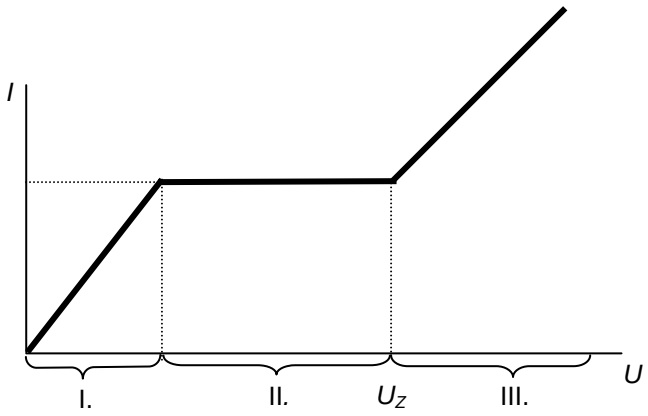
Initiated gas discharge – ionisation agent is needed to produce ions – flame, source of nuclear radiation, ...

Self-sustaining gas discharge – no ionisation agent needed, usually in strong electric field ions and electrons are accelerated so much that they can gain enough energy to cause further ionisation – chain ionisation

Ionisation chamber



the characteristics of an ionisation chamber



I. $I \approx U$ ... bigger U – more ions and electrons manage to get to the electrodes

II. $I=I_S$ (saturated current) ... all ions and el. produced during a certain time will get to the electrodes, I_S depends on .....

III. $U \rangle U_Z$ ... ions are accelerated so much that the discharge is self-sustaining (plasma = highly ionised gas during the s.-s. discharge)

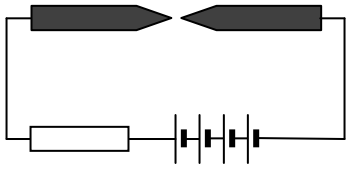
chain ionisation – finish the figure:

2. Gas discharge at different pressure

a) discharge in the air at p_s

- **arc discharge**

high *U* – electrodes in contact and then moved slightly apart – plasma (thousands kelvins) – intense source of light



use: in the past – lamps in cinema projectors
now – welding

http://www.youtube.com/watch?v=fRqj374cc2o&feature=related
http://www.youtube.com/watch?v=7cbP2_AMN7U
http://www.youtube.com/watch?v=eqRkEMfEtTo&NR=1
http://www.youtube.com/watch?v=UfiXtv9bJ4I
http://www.youtube.com/watch?v=4bBvmPRqfmo

- **spark discharge**

lasts for a short time, the source is discharged quickly, connected with sound

example: flash – clouds-earth $U \approx 10^9$ V, during 0.001s $I \approx 10^5$A

http://www.youtube.com/watch?v=BrQxOcPaM48

- **corona discharge**

in non-uniform electric field e.g. near tips or peaks at high potential
- ionization is possible only in a limited space around
- responsible for energy lost on transmitting cables in the air

http://www.youtube.com/watch?v=p9Wz1F92wXs&feature=related – recorded on a special sensitive film – can be seen easily

b) discharge in the air at $p < p_s$ and in gases

discharge tube - glass tube with electrodes sealed inside
either air at low pressure or gas as a medium in the tube

http://www.youtube.com/watch?v=Roc4RajQDhY – gradually decreasing pressure of air – try to describe the differences and find when would you use it as a source of light

- **glow discharge**

in the air when $p \approx 1\,000$ Pa, 100 Pa – small current (μA), cold electrodes – pink column

different gases give out different colours of the discharge – Ne, H_2, O_2, ... $U \approx 100$ V

use: discharge tubes – source of light when coated inside
neon signs
control lights in the past (light in staircase switches, now replaced by LED)

- **cathode rays**

http://www.youtube.com/watch?v=XU8nMKkzbT8
http://www.youtube.com/watch?v=aaWsK2TXUN4&feature=related

When $p \approx 2$ Pa, $U \approx 10\,000$ V – electrons are rejected from cathode (-) when positive ions hit it. Electrons travel through the tube towards anode (+). Cathode is sometimes heated to release electrons by thermionic emission (see Y6)

use: screen of oscilloscopes and cathode-ray tubes, where electrons are accelerated in a tube with almost vacuum inside and deflected by electric fields. These fields can be replaced by magnetic fields – sets of coils – used in TV sets. Some sensitive material (ZnS) which can produce light when electrons strike it coats the inside of the tube.

Questions:
1. Self-sustaining gas discharge – explain the importance of ionization agent and chain ionization for the discharge. Can the current be constant when voltage rises?

2. Initiated gas discharge - explain the importance of ionization agent and chain ionization for the discharge. Can the current be constant when voltage rises?

3. Saturated current – explain the phenomenon. Does it need ionization agent?

4. Arc discharge, spark discharge and corona discharge – explain the main properties of the discharge, mention which type of field is formed and where can we use or find them.

5. Glow discharge – describe the apparatus we can use to make it. What is the medium in the tube? How can we use it?

6. Cathode rays – what is the difference between cathode rays and glow discharge? What is the nature of cathode rays? Where can we use them?

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