Electrical Discharge through gases at various pressures

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The flow of electric current through a gas at high potential difference and low pressure due to ionization of the gas is called electrical discharge through a gas. Electrical discharge through gas can be observed in a special type of device called the discharge tube. Discharge tube consists of a glass tube with two electrodes maintained at high potential difference (10-15 kV) at two ends of the tube of length of about 30-50 cm and diameter of 3-5 cm as shown in Fig.1. It is also provided with a vacuum pump to vary the pressure of gas inside it and a pressure gauge (manometer) to measure the pressure in it.

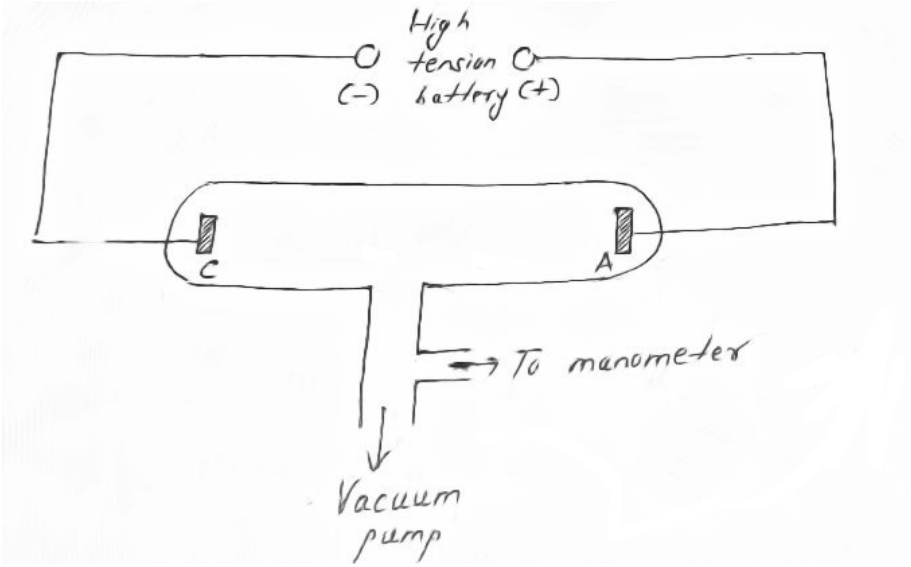
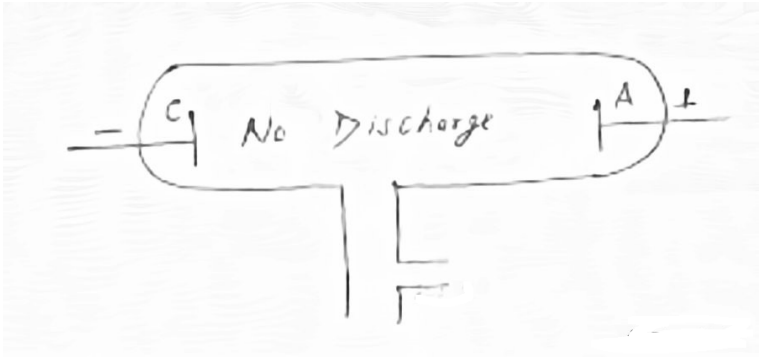


Fig.1: Discharge Tube

The electrical discharge through gases can be studied at following pressure:

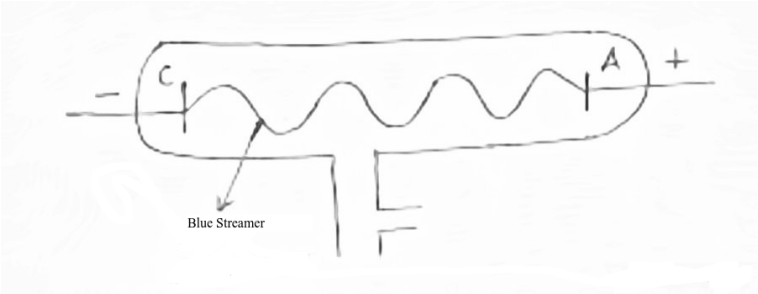
1. **At pressure of 760 mm of Hg**



When the pressure inside the discharge is at atmospheric pressure or 760 mm of Hg, gas molecules inside it cannot be ionized due to low mean free path of the electrons.

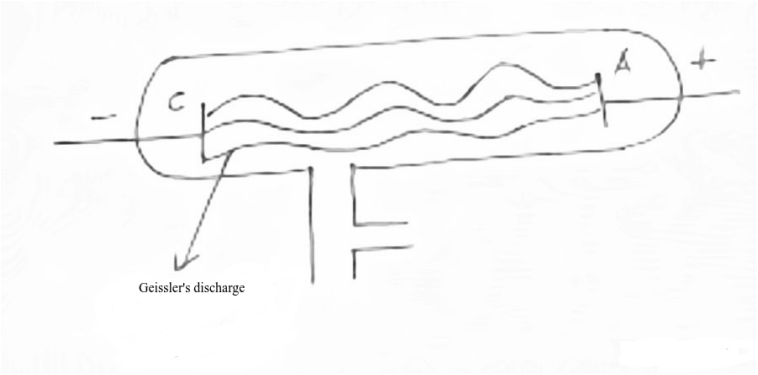
So, the electrical discharge does not take place as the gas atoms in the discharge tube collide with the electrons preventing them from reaching the anode. (manometer) to measure the pressure in it.

2. **At pressure of 10 mm of Hg**



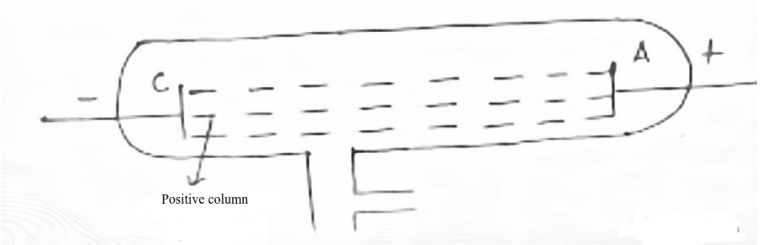
When the pressure inside the discharge tube is reduced to 10 mm of Hg, discharge starts with irregular luminous thin lines called blue streamers forming between electrodes. Its path is zig-zag with crackling noise being produced.

3. **At pressure of 5 mm of Hg**



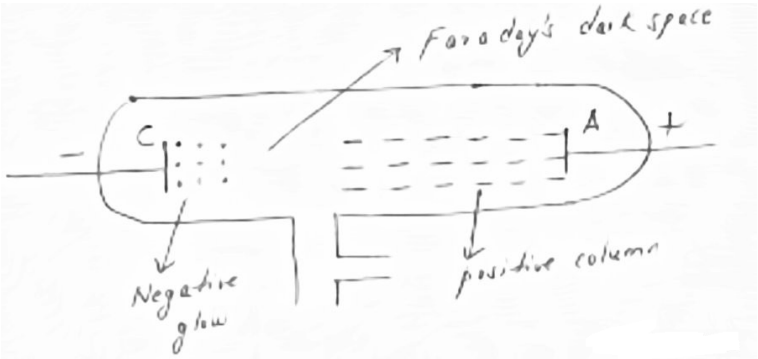
When the pressure inside the tube is reduced to 5 mm of Hg, the blue streaks broaden out into a luminous column which is bright and steady. The luminous column is called Geissler's discharge. The color of discharge depends on the nature of the gas used in the tube.

4. **At pressure of 2 mm of Hg**



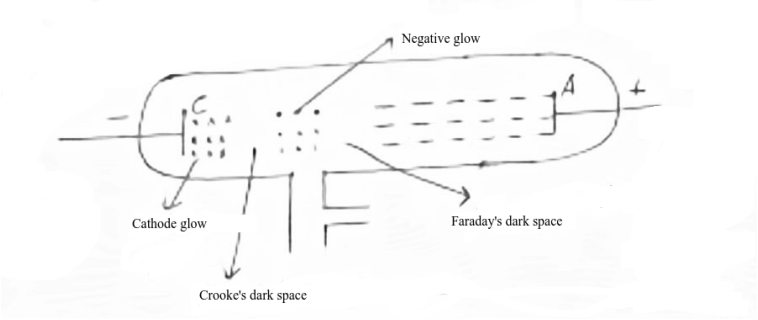
When the pressure inside the tube is reduced to 2 mm of Hg, a luminous column called positive column appear between cathode and anode.

5. **At pressure of 1 mm of Hg**



When the pressure inside the tube is reduced to 1 mm of Hg, the positive column is separated from cathode forming a bluish luminous glow near cathode called negative glow. The space between them is called Faraday's dark space.

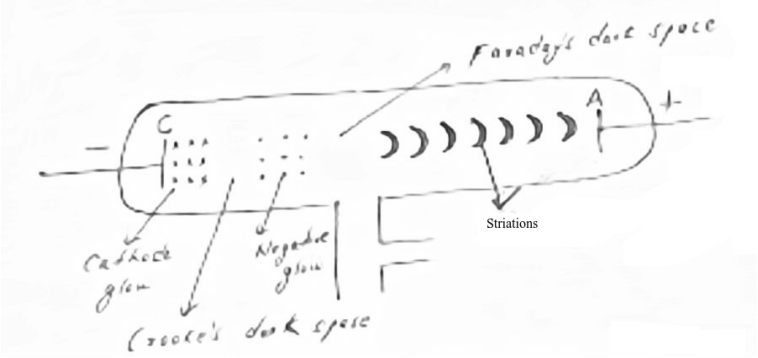
6. **At pressure of 0.5 mm of Hg**



When the pressure inside the tube is reduced to 0.5 mm of Hg, the negative glow leaves the cathode and moves towards anode. At the cathode, at the same time, another glow

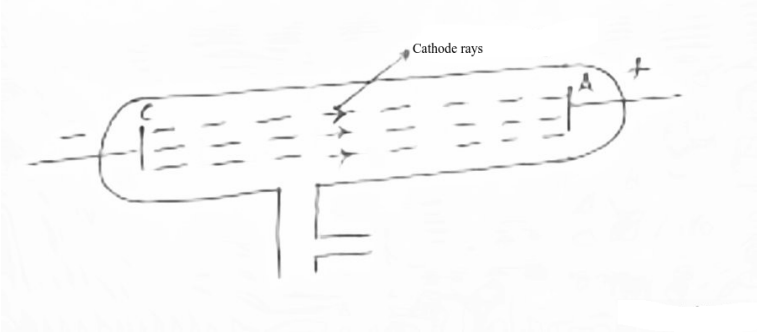
called cathode glow appears. The dark space between negative glow and cathode glow is called Crooke's dark space.

7. **At pressure of 0.05 mm of Hg**



At a pressure of 0.05 mm of Hg, the positive column shortens and breaks into equally spaced alternate bright and dark bands called striations whereas other phenomenon inside it remain unchanged.

8. **At pressure of 0.01 mm of Hg**



When the pressure inside the tube is reduced to 0.01 mm of Hg, the striations, Faraday's dark space, negative glow and cathode glow disappear. The whole tube is filled with Crooke's dark space. The inner discharge tube around the anode plate glows due to the continuous flow of electron beam from cathode to anode called cathode rays.

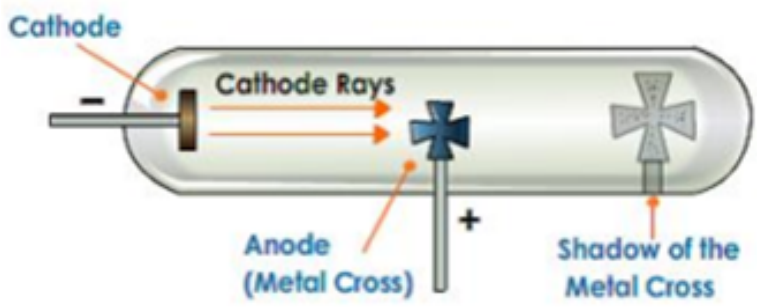
9. **Pressure below 0.01 mm of Hg**
When the pressure is reduced below 0.01 mm of Hg, the discharging phenomenon stops as there won't be enough atoms to ionize.

Cathode Rays

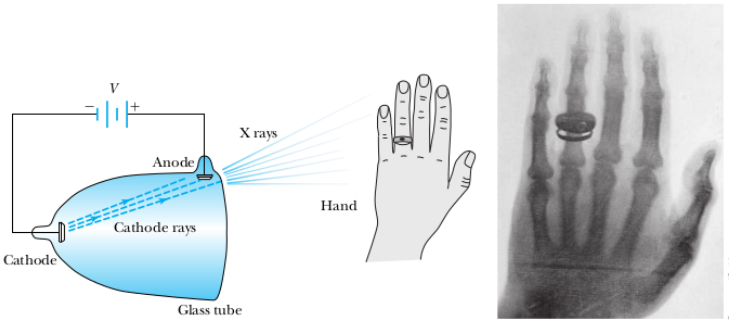
The invisible rays emitted from the cathode of a discharge tube when the pressure is maintained at about 10^{-2} mm of Hg under high potential difference of 10-15 kV are called cathode rays. These rays are the streams of electrons.

Properties of Cathode Rays

1. Cathode rays are the streams of fast moving electrons emitted from the cathode.
2. The speed of cathode rays is about $(1/10)^{th}$ speed of light.
3. The travel in a straight line and cast sharp shadow of objects in their path.

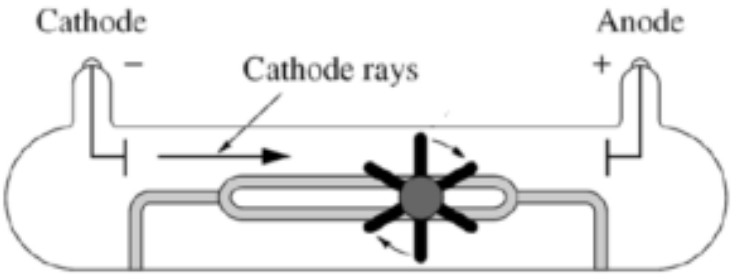


4. They produce fluorescence in many substances when they fall on them.
5. They produce a blackening on a photographic plate when they are incident on it.
6. They can ionise the gases through which they pass and make them conducting.
7. They generate heat when they fall upon matter due to the conversion of kinetic energy into heat energy.
8. They are deflected by both electric and magnetic fields which provides a evidence that they possess mass and their deflection shows that they are negatively charged particles.
9. The energetic cathode rays can produce X-rays when they strike a metallic target like tungsten, platinum etc. in a vacuum.



10. Their penetrating power is low, however they can penetrate very thin sheets of paper.

11. On placing a light paddle wheel in the path of cathode rays in a discharge tube, the blades of paddle wheel rotate. It shows that cathode rays possess mechanical energy.



12. The nature of cathode rays does not depend on the nature of the gas and the material of the electrodes used in the discharge tube.