Related Topics

Ionizing effect, generation of X-radiation.

Principle

As well as the outgoing radiation from a radioactive emitter is able to ionize air, so also X-radiation shows an ionizing effect. When air is penetrated by X-radiation, it is electrically conductive.
This is tested on a charged electroscope.

Equipment

1	XR 4.0 expert unit	09057-99	1*	High voltage supply unit, 0-10 kV	13670-93
1	X-ray plug-in unit with a tungsten X-ray tube	09057-80	1*	High-value resistor, 50 megOhms	07159-00
1	X-ray diaphragm tube, 5 mm	09057-03	2*	Insulating stem	06021-00
1	Electroscope, Kolbe type	07120-00	1*	Barrel base PHYWE	02006-55
1	Conductor ball, d = 40 mm	06237-00	1*	Conductor ball, d = 20 mm	06236-00
1	Digital stop watch, 24 h, 1/100 s & 1 s	24025-00	1	Conductor ball, d = 40 mm	06237-00
1	Banana plugs, 4 mm, set of 4	29417-00	1	Connecting cord, 32 A, 1000 mm, red	07363-01
1	Copper wire, d = 0.5 mm, l = 50 m	06106-03	1	Connecting cord, 32 A, 100 mm, blue	07359-04
1	Felt, natural hair, 10 x 10 cm	06204-00		Connecting cord, 32 A, 500 mm, green-	
1	Rod, amber, l = 100 mm, d = 10 mm	06260-00	1	yellow	07361-15
	* alternative				

This experiment is included in the upgrade set “XRD 4.0 X-ray dosimetry”.

Fig. 1: P2540040

Task

1. Illustrate the ionizing effect of X-radiation with the aid of an electroscope.

2. Examine the influence of the anode voltage and amperage on the duration until the electroscope is discharged.

Set-up

Fix a diaphragm tube in the X-ray outlet tube (5 mm tube diameter).
The electroscope with the plugged conductor ball is placed in the experimenting area.
An approximately 20 cm long piece of copper wire is bent so that the two wire ends can be plugged together in a banana plug.
The banana plug with the wire loop is plugged into the free transversal bore of the electroscope.
The wire loop is bent so that it is hit by the X-ray beam.

Note

Details concerning the operation of the X-ray unit can be found in the respective operating instruction.

Procedure

Set the anode voltage and current in the “X-ray parameters” menu. Select a voltage of 35 kV and a current intensity of 1 mA.
Charge up the amber rod by firm rubbing with the felt. Using the rod, charge the electroscope. Maybe there is a need to repeat this procedure until the electroscope is fully charged.
After the pointer of the electroscope has come to rest, you wait some time and then close the door of the experimental area. Switch on the X-radiation and start the stopwatch.

The experiment should be repeated several times with different voltages (steps of 5 kV, current constant) and current intensities (steps of 0.1 mA, voltage constant).

Alternative Procedure

Alternative you can use the high voltage power supply to charge the electroscope. Choose a voltage of 0.9 kV for charging.

Theory

X-rays are not charged since they are not deflected by electric or magnetic fields even so they are able to discharge the electroscope.
Roentgen discovered this effect in one of his first experiment 1895 and suspect that the discharge occurred because the X-ray made the air around conductive. The X-radiation produces within the air and the migration of this ions induces the conductivity of the gas.

The importance of X-rays to medical therapy is based on this ionizing effect.
By improper handling of X-radiation there is the danger of cell damages. Therefore, the legislature requires strict safety precautions when handling with X-radiation.

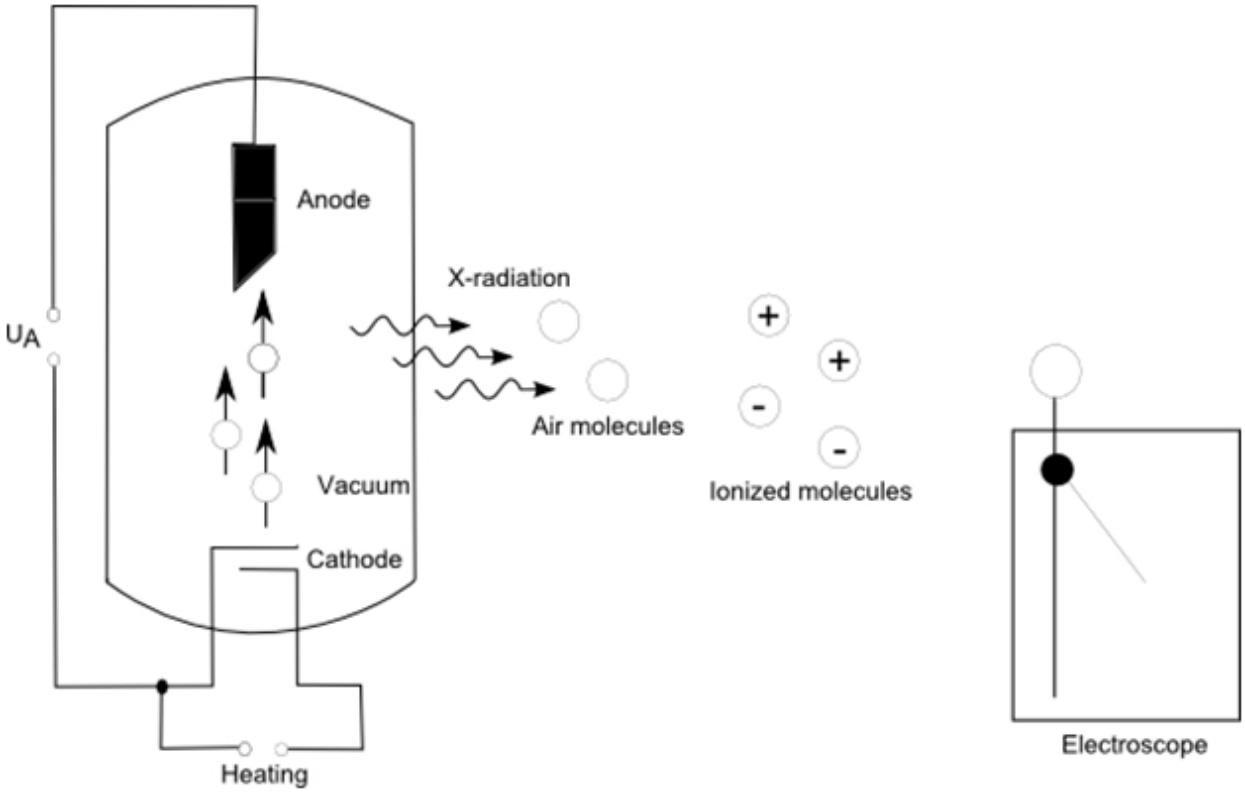

Fig. 2: Schematic diagram of the experiment.

Evaluation

When the X-radiation is switched off, the charged electroscope is not discharged. When the X-radiation is switched on, the charged electroscope discharges within a short time.

The air in the vicinity of the wire loop is traversed by the X-rays and ionized. Thus it is conductive to a certain grade, so that the charge flows from the electroscope.

The time needed for discharging the electroscope depends on the used current and voltage. The lower current and voltage are, the longer it takes to discharge the electroscope.

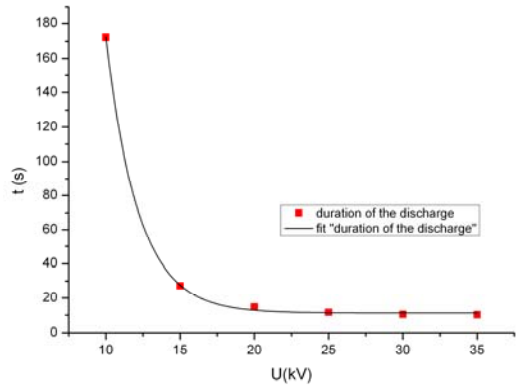

Fig. 3: Speed of discharge as a function of U_A.

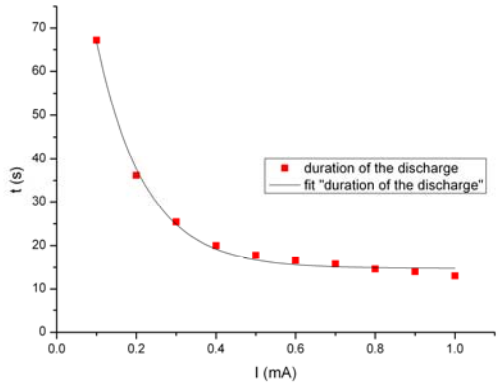

Fig. 4: Speed of discharge as a function of I_A.

Once the voltage falls below a certain value (approx.6 kV with I_A = 1.0 mA) there is no discharge. This means that below this value no X-radiation is generated.