Experiment 15

Ionisation of Air by X Rays

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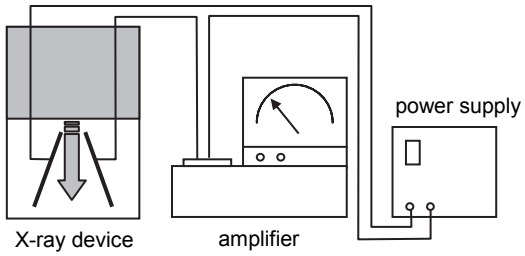
Aim

- To determine the relation between ionisation current *I* and voltage *U* across two capacitor plates when X rays pass between the plates.
- To measure the exposure rate of the X-ray tube.

Set-up

The X-ray tube is contained in a case with a chamber of lead glass at the front. This glass absorbs almost all of the X rays emitted by the tube. Inside the chamber two capacitor plates are connected to a variable power supply. The X rays ionise the air between the plates. The resulting ionisation current is amplified and measured by an ammeter.



Note: You activate the X-ray device by pushing the **red button** on top of the device. When you let go of this button, the device switches off. For each observation, do not activate the device longer than **5 s** in order to prevent overheating the X-ray tube.

Read the introduction on page 18 of the booklet *ISP Experiments* about the emergence of an ionising current between the capacitor plates.

Measurements

1 Set the voltage across the capacitor plates to 0 V and, if necessary, adjust the current amplifier to a reading of 0 A.

2 Set the voltage *U* across the capacitor plates to 20 V, activate the X-ray device, read the ionisation current *I*, and deactivate the X-ray device. Record your measurement in the table below.

3 Repeat this measurement for the other values of the voltage *U* as indicated in the table below.

U (V)	20	40	70	100	150	200	250	300	350	400	450	500	650	800
I (10^{-9} A)														

Assignments

1 Plot your measurements (ionisation current *I* as a function of voltage *U*) in the graph (right).

2 Explain why, at a particular value of the voltage, the ionisation current between the capacitor plates reaches a maximum (the so-called saturation current).

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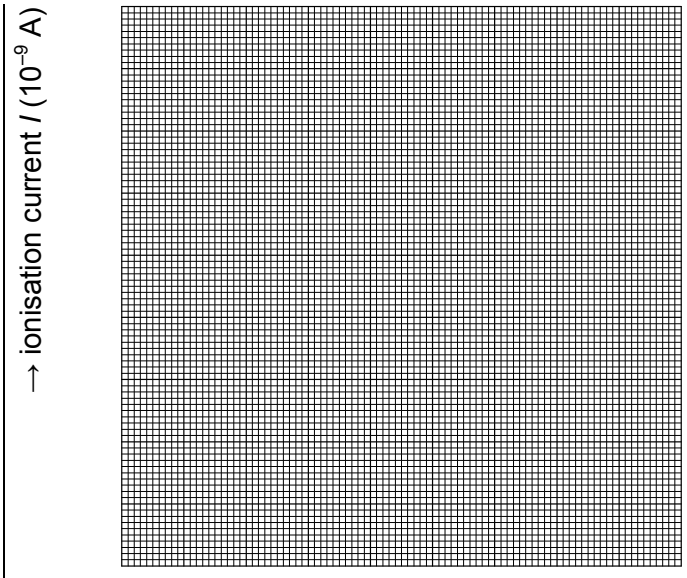

With the result of these measurements, the rate of exposure of the X-ray device can be determined. The *exposure* is the charge per kg air caused by the X rays. The unit of exposure is thus coulomb (the unit of charge) per kg (the unit of mass). Or, for short: C/kg. The *exposure rate* then is the exposure per second, with the unit C/kg·s). From the exposure rate of the X-ray device, the radiation dose caused by the X rays can be calculated.

3 Determine the exposure rate of the X-ray device (inside the chamber) by completing the following sentences:

- The saturation current was found to be …… A (see Assignments 1 and 2).
- Therefore, the charge formed per second in the air between the capacitor plates is …… C/s.

Note: The current (in A) is defined as the amount of charge (in C) passing through the cross section of a wire per second. Or, in the case of this experiment: the amount of charge formed between the capacitor plates per second.

- There is $2.27 \cdot 10^{-4}$ kg of air between the capacitor plates. Now, calculate the exposure rate of the X-ray device.

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Exposure rate: …… C/kg·s

4 An exposure of 1 C/kg corresponds with an equivalent dose of 40 Sv. Calculate for how long the X-ray device in this experiment should be switched on to give an equivalent dose that is comparable to the equivalent dose of 1 mSv that one gets from making an X-ray photograph of a broken leg.

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