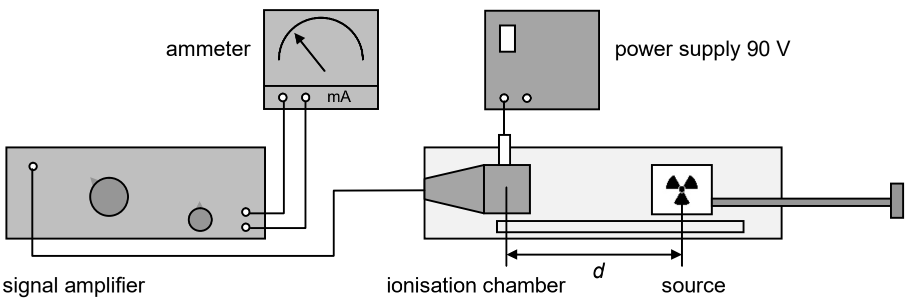
Experiment 1

Range of Alpha Particles in Air

First read the introduction at experiment 1 in the booklet *ISP Experiments* about the range of α particles in air.

Aim To measure the range in air of α particles emitted by a source of radium-226.

Set-up The set-up consists of a radium-226 (^{226}Ra) source and an ionisation chamber. In such an ionisation chamber the particles cause an ionisation of the air in the chamber, which induces an ionisation current. The distance *d* between the source and the ionisation chamber is adjustable between 2.5 en 8.0 cm and can be read on a scale. In this scale the average penetration depth of the α particles in the ionisation chamber has been taken into account. The amplified ionisation current *I* is to be read on an ammeter.
In this set-up it is not possible to measure (and thus to correct for) the background radiation, because both the source and the ionisation chamber are fixed within the equipment set-up.



With the equipment set-up, the range *R* of α particles in air can be determined by measuring the ionisation current *I* as a function of the distance *d* between source and ionisation chamber.

Research Question

- Draw up a research question fitting the aim and equipment set-up of this experiment

Hypothesis

- Draw up an argued hypothesis about the relation between the ionisation current *I* and the distance *d* between source and ionisation chamber.
- Give this hypothesis also in the form of a sketch of the relation between these quantities in an *I*,*d*-graph.
- Also draw up a hypothesis about the order of magnitude of the range *R* of α particles in air.

Plan of Work

- Draw up a plan of work for the investigation with the given equipment set-up.
- In this plan of work, indicate how you will vary which quantities in order to be able to check your hypothesis.
- Prepare an (empty) table for recording your measurements.
- Indicate whether the experiment will contribute to the radiation dose you receive during the laboratory session. And, if so: how you can take care that this radiation dose stays as low as possible.
- Discuss your research question, hypothesis and corresponding plan of work with your teacher or the school's laboratory technician.
- If necessary, review your research question, hypothesis and/or plan of work.

Investigation

- Carry out the investigation according to your plan of work. During the laboratory session, take care of an adequate radiation protection.

Data Processing

● Process your measurements in order to check your hypothesis, and to answer your research question. The box below gives some instructions for such data processing.

Instructions

● Plot your measurements in a graph.

> From this graph, determine the range *R* in air of the α particles emitted by ^{226}Ra.

● The ^{226}Ra in the source decays through a large number of steps to finally ^{206}Pb. This *decay series* of ^{226}Ra is given below:

$$^{226}_{88}\text{Ra} \rightarrow {}^{222}_{86}\text{Rn} \rightarrow {}^{218}_{84}\text{Po} \rightarrow {}^{214}_{82}\text{Pb} \rightarrow {}^{214}_{83}\text{Bi} \rightarrow {}^{214}_{84}\text{Po} \rightarrow {}^{210}_{82}\text{Pb} \rightarrow {}^{210}_{83}\text{Bi} \rightarrow {}^{210}_{84}\text{Po} \rightarrow {}^{206}_{82}\text{Pb (stable)}$$

The source thus contains, next to the instable ^{226}Ra and the stable ^{206}Pb, also all instable decay products from the decay series above. Each of those decay products in its turn decays while emitting a specific type of radiation with a specific energy. The emitted radiation can be derived from the given decay series, and the energy can be found in the *Table of Isotopes* in the booklet *ISP Experiments*.

> Determine which isotopes in the decay series of ^{226}Ra emit α radiation, and, for each of these isotopes, look up the energy of the emitted α particles.

● The ionising capacity and the range of an α particle both depend on the particle's energy. If the energy of an α particle decreases as a result of energy transfer when ionising nitrogen and oxygen molecules in the air, its ionising capacity first gradually increases. After the energy of the α particle has decreased below a certain level, it has completely lost its ionising capacity. The distance at which this happens – so, the range of the α particle – depends on the particle's energy when leaving the source: the larger its energy is, the larger is its range.

> Explain the shape of the graph showing the relation between the ionisation current *I* and the distance *d* between source and ionisation chamber.

> Check your explanation with the help of the background information about the range of α particles in air on the ISP website (in Dutch): stralenpracticum.nl > students > background information > range of α particles in air. This background information is also available as an information sheet (in English) at the equipment set-up.

Extra question

In the medical world protons are often used instead of alpha-particles for radiation treatment. Look at the ionization curve on the information sheet (figure 1) again. When you use protons instead of alpha-particles, the global shape of the curve remains the same. However, protons from a proton source are accelerated in a particle accelerator. Can you now explain why protons are increasingly being used in medical applications?

Report

● Write a report about this investigation. This report presents your *research question*, *hypothesis*, (processed) *measurements* and *conclusion* about the hypothesis being confirmed or not.

Note

In the Wilson chamber of Experiment 9 the range of α particles in air is directly visible.