Experiment 19

Range of Alpha Particles and Air Pressure

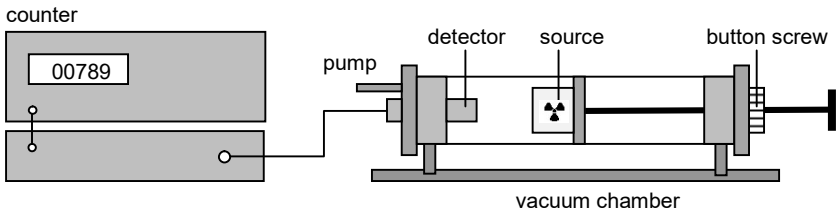
First read the introduction at experiment 19 in the booklet *ISP Experiments* about the range of α particles in air and air pressure.

Aim

To determine the relation between the range of α particles in air and air pressure.

Set-up

The set-up consists of a detector, a pulse counter, a vacuum chamber and a source of americium-241 (^{241}Am). The vacuum chamber can be closed with a button screw, which should not be turned too tight. The air pressure in the vacuum chamber can be adjusted with a hand-operated vacuum pump, and can be read on a pressure meter.
The distance between source and detector is adjustable between 3.0 and 7.0 cm.
In this set-up it is not possible to measure (and thus to correct for) the background radiation, because both the source and the detector are fixed within the vacuum chamber.



With the equipment set-up, the range *R* of α particles in air can be measured as a function of air pressure *p*. Start, for example, with a distance of 3.0 cm between source and detector. Then start the counter, reduce the air pressure in the vacuum chamber by pumping slowly, and stop pumping when the counter just starts counting. At this value of the air pressure, only the α particles emitted with the highest energy reach the detector. Therefore, the range *R* of the α particles then equals the distance of 3.0 cm between source and detector.

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 range *R* of α particles in air and air pressure *p*.
- Give this hypothesis also in the form of a sketch of the relation between these quantities in an *R*,*p*-graph.
- Also draw up a hypothesis about the order of magnitude of the range *R* of α particles in air at normal atmospheric pressure.

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 the graph, determine the relation between the range R of α particles and air pressure p.

- From the R,p-graph of your measurements it appears that the relation between range R and air pressure p probably is *inversely proportional*. In a formula:

$$R = \frac{c}{p} = c \cdot \frac{1}{p}$$

In this formula c is a proportionality constant.

> Explain how this follows from the R,p-graph.

> Check whether there is indeed an inversely proportional relation by plotting the range R versus $1/p$.

> From the graph, determine the proportionality constant c in the formula of the relation between range R and air pressure p.

- With the found proportionality constant c the relation between range R and air pressure p can be given in the form of a formula.

> With this formula, calculate the range R of α particles in air at normal atmospheric pressure.

Extra question

During the decay of AM-241 gamma radiation is also released. This however has almost no influence on the measurement. Can you explain why?

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 at normal atmospheric pressure is directly visible.