Experiment 2B

Radioactive Decay of Radon-220

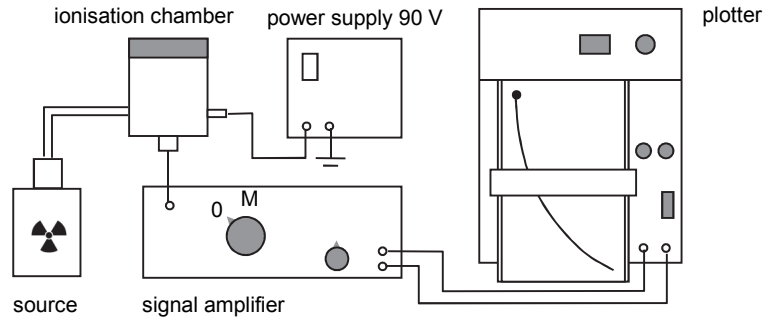
Name:
……...

Aim

To measure the half-life of radon-220.

Set-up

The set-up consists of an ionisation chamber that is filled with radon gas from a small plastic bottle containing a source of thorium-232 (^{232}Th). The α particles emitted by the radon-220 (^{220}Rn), which is itself a decay product of ^{232}Th, ionise the air in the ionisation chamber. The charge produced is displayed as a current on a plotter after amplification by a signal amplifier. The value of the current I (the displacement of the plotter pen) at time t is a measure of the number of radioactive radon nuclei N_t at that moment. Because: the larger the number of radioactive radon nuclei is, the larger is the ionisation of the air and so the larger is the current measured.



Read the introduction on page 4 of the booklet *ISP Experiments* about the decay of radioactive substances.

Measurements

1 Switch the button on the signal amplifier to 0. Adjust the position of the plotter pen to 0% with the button 'zero' on the plotter. Switch the button on the signal amplifier to M. **Do not further adjust the settings of the signal amplifier and the plotter**.

2 Open the tube clip, gently squeeze the small plastic bottle once until the pen gives a maximum result (100%), and close the tube clip. Use the 'pen lift' to place the plotter pen on the paper.

3 Quickly switch on the plotter's paper transport by pressing the button 'record on/off'. The transport speed of the paper is 1 mm/s. The plotter pen will record the decay of ^{220}Rn over time.

4 Stop the plotter when its pen has reached the 10% mark on the paper by (again) pressing its button 'record on/off'. Move the paper forward until the recorded graph is completely outside the plotter. Carefully tear off the paper. Finally, switch the button on the signal amplifier from M to 0.

Assignments

1 The graph on the plotter paper shows the decay of ^{220}Rn. First, draw a flowing curve through the graph in order to average the statistical fluctuations. Then add the x and y axes to the graph: one for the time t (in s), and the other for the plotter pen displacement (0 to 100 %). Remember that the transport speed was 1 mm/s.

2 Determine the half-life $t_{1/2}$ of ^{220}Rn by choosing a value of the plotter pen displacement and measuring in the graph after how much time this value is halved. Do this three times for three different values of the plotter pen displacement. Record your measurements below (A, B and C), and calculate the average value of the half-life of ^{220}Rn.

The plotter pen displacement decreased

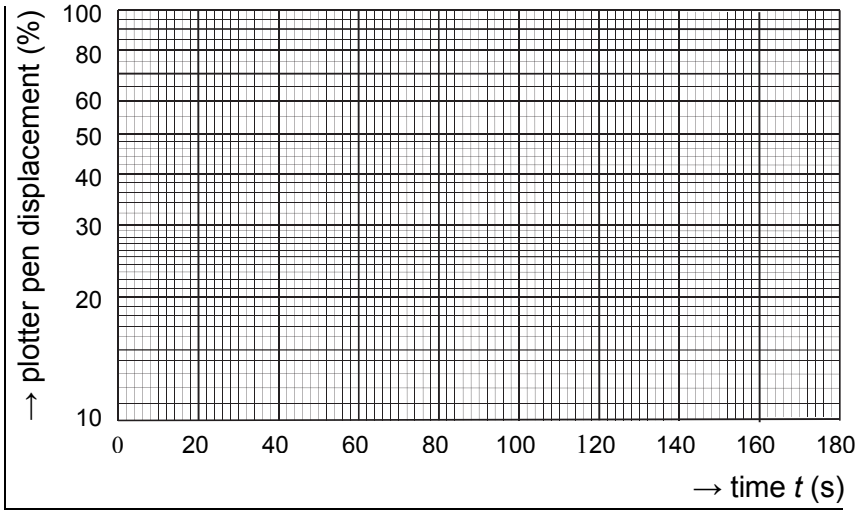
A from …..… to …..… % in ……. s

B from …..… to …..… % in ……. s

C from …..… to …..… % in ……. s

Average half-life $t_{1/2}$ of ^{220}Rn:

$t_{1/2}$ = ……. s



3 Transfer the recorded graph of the plotter to single logarithmic graph paper (left). What is special about this graph?

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4 Determine from this new graph the half-life $t_{1/2}$ of ^{220}Rn:

$t_{1/2}$ = ……. s

5 In assignments 2 and 4 you used two different ways to determine the half-life of ^{220}Rn. Which of these is the most accurate, and why?

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6 What is the literature value of the half-life of ^{220}Rn according to the table of isotopes in the booklet *ISP Experiments* (page 30)? What is the difference between this and your own value?

Literature value: …… s. Deviation: …… %

7 Calculate the time in which the activity of ^{220}Rn will decay to 6.25% of the original activity (100%).

Time: …… s

8 ^{220}Rn is a so-called daughter product of ^{232}Th, which decays into the stable ^{208}Pb according the decay series below.

$^{232}_{90}\text{Th} \xrightarrow[1.4\cdot10^{10}\ \text{a}]{\alpha} {}^{228}_{88}\text{Ra} \xrightarrow[\ldots\ldots]{\ldots} {}^{228}_{89}\text{Ac} \xrightarrow[\ldots\ldots]{\ldots} {}^{228}_{90}\text{Th} \xrightarrow[\ldots\ldots]{\ldots} {}^{224}_{88}\text{Ra} \xrightarrow[\ldots\ldots]{\ldots} {}^{220}_{86}\text{Rn} \xrightarrow[\ldots\ldots]{\ldots}$

$^{216}_{84}\text{Po} \xrightarrow[\ldots\ldots]{\ldots} {}^{212}_{82}\text{Pb} \xrightarrow[\ldots\ldots]{\ldots} {}^{212}_{83}\text{Bi} \xrightarrow[\ldots\ldots]{\ldots} {}^{212}_{84}\text{Po} \xrightarrow[\ldots\ldots]{\ldots} {}^{208}_{82}\text{Pb}$ (stable)

Complete the decay series of ^{232}Th above. In this decay series you put the particle (α or β) above the arrow and the half-life below the arrow, as already done for the first decay step. You can find the necessary half-life values on page 30 of the booklet *ISP Experiments*.

9 What can you say about the danger of inhalation of ^{220}Rn? Motivate your answer.

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Note

See the booklet *ISP Experiments* (pages 31-32) for the reasons of using single logarithmic graph paper in determining the half-life of a radioactive isotope.