Experiment 20

Radioactive Decay of Protactinium-234

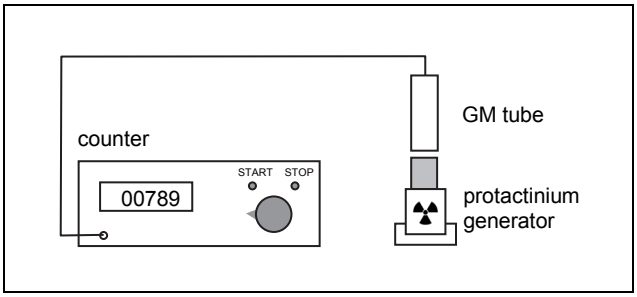
Name: ……..

Aim

To measure the half-life of protactinium-234.

Set-up

The set-up consists of a Geiger-Müller tube, a pulse counter and a protactinium generator (^{234}Pa).
Note: The generator has no removable lid. So, do not try to open up the generator in one way or another.



Read the introduction on page 24 of the booklet *ISP Experiments* about the operation of the protactinium generator.

Measurements

1 Measure the intensity I_b of the background radiation (in pulses per 10 s) three times, and record your measurements in the table below. Calculate the average intensity $I_{b,avr}$ of the background radiation (in pulses per 10 s). Record the result in the table below.

I_b (pulses/10s)				$I_{b,avr}$ (pulses/10s)	

2 By thoroughly shaking the protactinium generator, mix the two liquids it contains. Position the generator underneath the GM tube, and wait for about ten seconds. Then simultaneously start the counter and the stopwatch. The counter will automatically stop after 10 s. Let the stopwatch continue to keep track of the time elapsed. Record the measured radiation intensity I (in pulses per 10 s) in the table below. Restart the counter at t = 20 s on the stopwatch. The counter resets itself if you push the start button. In this way, complete your measurements as indicated in the table below. And finally, correct for the background radiation: $I_{cor} = I - I_{b,avr}$.

t (s)	0-10	20-30	40-50	60-70	80-90	100-110	120-130
I (pulses/10s)							
I_{cor}							

t (s)	140-150	160-170	180-190	200-210	220-230	240-250	260-270
I (pulses/10s)							
I_{cor}							

Assignments

1 Plot your measurements (intensity I_{cor} as a function of time t) in the graph on the other side of this worksheet.

2 Determine the half-life $t_{1/2}$ of ^{234}Pa by choosing a value of the intensity I_{cor} and measuring in the graph after how much time this value is halved. Do this three times for three different values of the intensity. Record your measurements below (A, B and C), and calculate the average value of the half-life of ^{234}Pa.

The intensity I_{cor} decreased

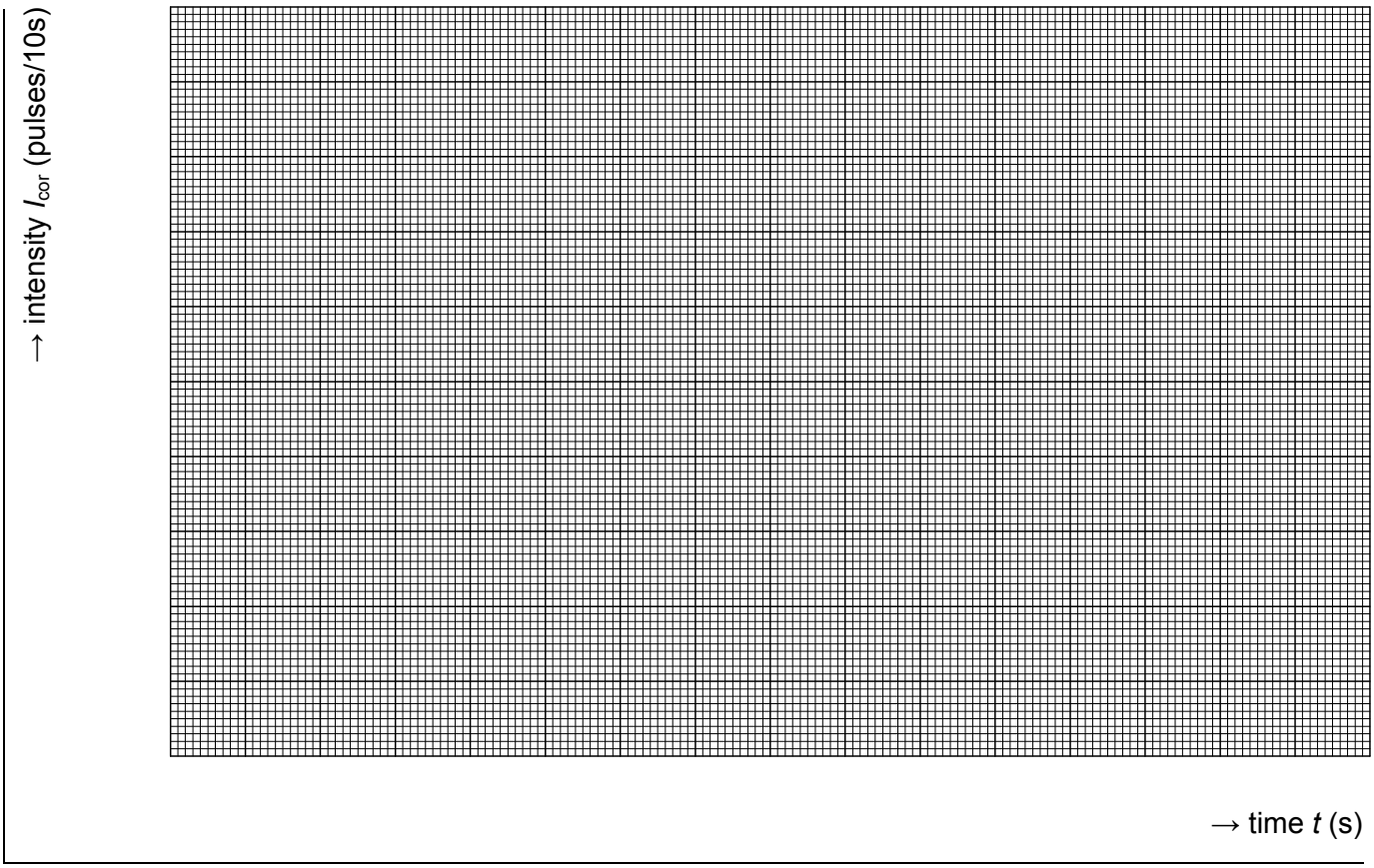
A from …… to …… in …… s

B from …… to …… in …… s

C from …… to …… in …… s

Average half-life $t_{1/2}$ of ^{234}Pa:

$t_{1/2}$ = …… s



3 Below is shown part of the decay series of uranium-238 in the protactinium generator.

$$^{238}_{92}U \xrightarrow[4.5{\cdot}10^{9}\text{ years}]{\text{.....}} {}^{234}_{90}Th \xrightarrow[24\text{ days}]{\text{.....}} {}^{234}_{91}Pa \xrightarrow[\text{.....}]{\text{.....}} {}^{234}_{92}U \text{ .....} \quad \text{(decay continues)}$$

Above the arrows in this decay series, record the kind of radiation emitted (α or β). And complete the decay series with the half-life of ^{234}Pa.

4 Imagine doing this experiment a second time after 24 days, using the same protactinium generator. Explain with the help of the decay series of ^{238}U what the results of that experiment will be in terms of measured radiation intensity.

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5 The protactinium generator consists of a plastic bottle containing two liquids. When we put these liquids in a glass bottle, the measured radiation intensity will be considerably lower. Explain this.

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