Notes For Use

R01192 Protractinium Generator

Used for demonstration of the principles of radioactive decay and determination of the half-life of the element Protactinium.

What is a 'Protactinium Generator''?

The Generator comprises a chemical resistant bottle holding quantities of 2 mutually incompatible liquids, one floating on the other.

The lower phase comprises of a Uranium salt in hydrochloric acid. The upper phase is an organic olvent - coloured with dye for clarity.

A proportion of all natural Uranium atoms are of the radioactive variety Uranium238. These atoms are fundamentally unstable, and undergo a gradual irreversible process of radioactive decay, following the cycle:-

$$\text{Uranium238} \xrightarrow{-\beta} \text{Thorium234} \xrightarrow{-\beta} \text{Protactinium234} \xrightarrow{-\beta} \text{Uranium234}$$

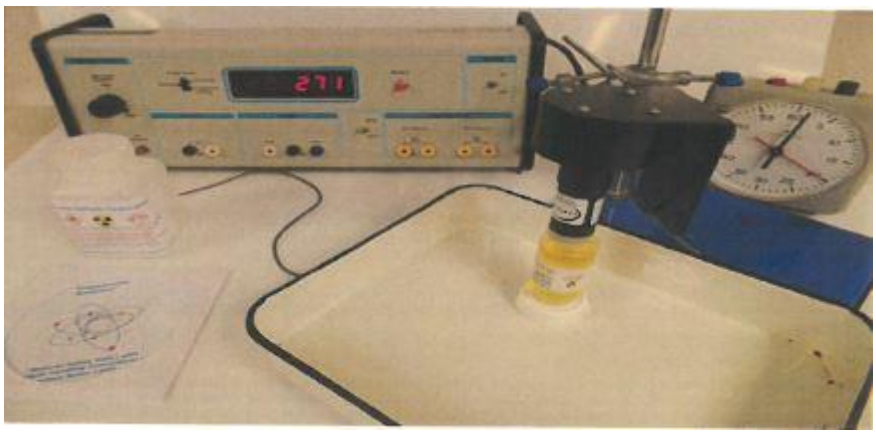
So at any time, within the lower liquid phase of the Generator, there is a mixture of all the above radionuclides undergoing a continuous cycle of production and decay.

However, using the Generator, it is possible to briefly isolate the Protactinium234 from the other radionuclides in order to study its rate of decay.

If the bottle is shaken, the Protactinium234 is extracted into the organic solvent,and when allowed to settle, remains in the upper layer until it decays away.

We can measure the rate at which this process takes place using a Geiger-Meter (GM) sensor and scaler/rate counter.

How is the Generator used?



The basic operation of the Generator is described as follows. (N.B. Always act in accordance with the Safe Handling Instructions).

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The highest counts are achieved when the unit is stood upright in the inverted position, resting on its cap, with the GM probe focusing on the wide base of the bottle. A Support Collar is provided to fit around the bottle cap, and stabilize the unit in that position.

However, it is advisable to restore the unit upright immediately upon completion of the experiment.

Fitting the Support Collar:



It is advisable to take readings of the background (stationary) activity count of the Generator at the very start of the experiment. So, without agitating the contents, position the Generator under the GM probe (directly touching the bottle) and take several counts over a standardized interval of around 15-20 seconds.

Position the Generator under the GM probe:

These readings should be averaged to establish a background correction factor for the Generator,which should be subtracted from subsequent activity measurements taken over similar intervals.

Then, whilst wearing gloves and eye protection and holding the Generator above a tray positioned to catch any unlikely spillage, agitate the bottle for 10-15 seconds to mix the two liquids. (N.B. Do not squeeze the bottle whilst shaking!)

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Shaking the Generator:

Position the GM probe against the generator, start the stopwatch and commence data collection.

Initially, the rate increases as the organic solvent floats to the top - the rate then falls as the Protactinium decays. It is worth noting the random nature of radioactive decay.

Cumulative readings should be taken over similar intervals (15-25 seconds), for up to 5 minutes, when activity will have almost ceased.

Then, all that is required to create a decay graph is to plot the corrected count readings against time, find the best fitting curve (i.e. negative exponential) and use it to estimate the half-life.

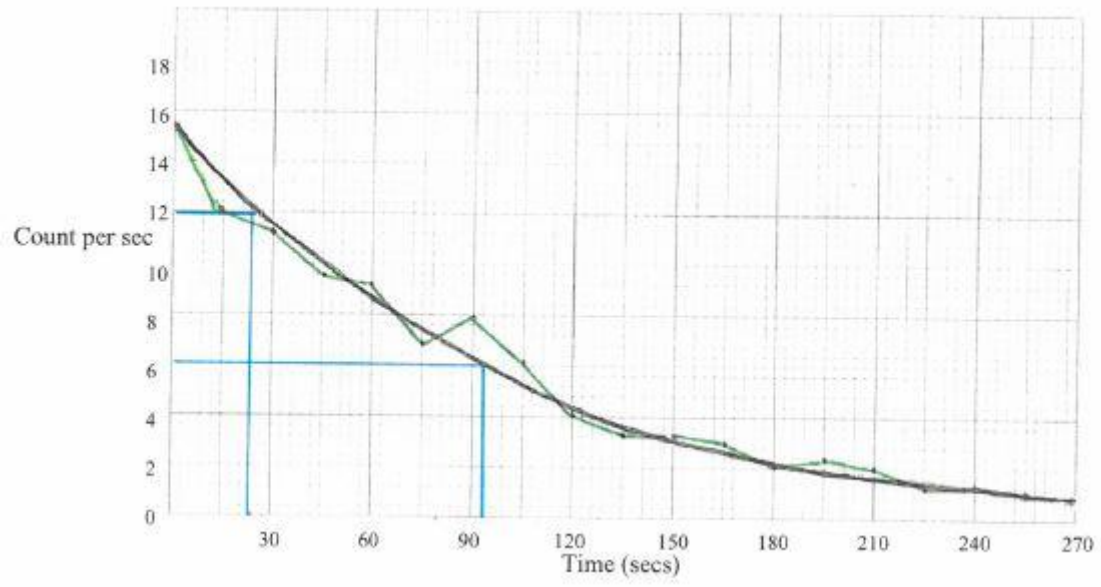
This can be done using the charting function within Microsoft Excel for instance.

As an alternative to the above manual procedure, there are a number of automated options for data capture and analysis.

The use of a data logger is particularly helpful for automatic collection of count readings, which can be captured at more frequent intervals than is feasible by the manual method, and if linked to a personal computer, graph plotting and data analysis software may be applied to produce rapid and reliable results. Refer to your equipment instruction manual for full details.

Graph of experimental results:

Protactinium Generator Tests



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Using the plot overleaf it can be deduced that the time for the count to fall from 12 per second to 6 per second is 93s - 24s i.e. 69s (expected value about 70s).

Repeating the process and measuring the time taken for the count to fall from 10 per second to 5 per second and 8 per second to 4 per second enables an average to be established.

There is a very wide range of equipment available to schools for conducting this experiment, and so it is not feasible to give a complete guide to their use here. However the same general principles of regular data collection/correction of counts/best fit curve/measurement of Half-Life are applicable to all systems.

Storage:

The generator should be stored in a cool room between 8°C & 15°C.

Optimum temperature for use:- 6°C - 20°C.

Supplier details:

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