**The Radioactivity Experiment – an exponential decay curve**

In this experiment a series of values of count rate (in counts per second or s-1) are recorded from the Geiger counter and ratemeter for a collimated beta source. The source is kept at a fixed distance from the counter and a number of sheets of identical paper are introduced (2 at a time, with tongs!) between the source and the detector. Owing to the random nature of radioactivity, 3 readings of count rate are taken for each number of sheets. The results are recorded below.

Complete the table with an average count rate value for each number of sheets, recorded to a consistent number of significant figures.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| N | Count rate / s-1 | | | Average / s-1 | ln(Average/s-1) |
| 0 | 391.2 | 398.2 | 390.2 |  |  |
| 2 | 372.0 | 365.3 | 367.2 |  |  |
| 4 | 339.7 | 346.5 | 345.5 |  |  |
| 6 | 319.6 | 313.2 | 319.1 |  |  |
| 8 | 293.2 | 287.4 | 283.9 |  |  |
| 10 | 280.1 | 282.0 | 280.1 |  |  |
| 12 | 256.0 | 259.0 | 262.6 |  |  |
| 14 | 246.4 | 247.2 | 244.9 |  |  |
| 16 | 233.0 | 236.5 | 240.5 |  |  |
| 18 | 219.6 | 221.2 | 224.9 |  |  |
| 20 | 205.8 | 207.1 | 211.0 |  |  |
| 22 | 191.5 | 188.6 | 188.3 |  |  |
| 24 | 176.3 | 178.0 | 175.9 |  |  |
| 26 | 165.3 | 165.5 | 164.3 |  |  |
| 28 | 157.6 | 156.8 | 155.1 |  |  |
| 30 | 143.9 | 142.6 | 142.7 |  |  |

Now plot a graph of average count rate on the y-axis against number of sheets on the x-axis. An **exponential** decay curve should be produced (similar to the graph you might have seen for radioactive decay and half live). Draw a freehand best fit **curve** to the data.

An analogous quantity to half-life is half value thickness, in this case the number of sheets to reduce the count rate reading to half. Use your curved graph to estimate a value for the half value thickness of the paper used, by drawing a horizontal line at a count rate equal to half the initial value.

**Linear analysis**

It is possible to produce a straight line graph (of negative gradient) from the data by taking the **logarithm** of the count rate. This is a technique that is commonly used in A2 Physics, however the theory of the technique is beyond the mathematical requirements of the AS year.

The type of logarithm used is the natural logarithm, or log to the base e. This function is represented by the “ln” button on scientific calculators (the inverse of this being the function ex). Locate this button and use it to calculate the natural logarithm of the average count rate for each reading. This should be recorded in the sixth column of the table headed ln(Average/s-1).

Now plot a graph of ln(Average/s-1) on the y-axis against N on the x-axis and a straight line graph should result.

Draw a best fit line and use a large triangle to measure the magnitude of the gradient – don’t worry about the negative sign or the units – both axes of this graph are just numbers and have no units.

In theory, the half value thickness number of sheets is given by:

H.V.T. = ln 2 / gradient

where ln 2 is simply the natural log of 2.

Calculate a value for the half value thickness from the gradient.

Does it agree with the value found from the curved graph?