The Geiger Counter

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Contents

1 Abstract

In this experiment the properties of the Geiger Counter were investigated. A Carbon-14 radioactive source was used to calculate the 'dead-time? of the counter. The half life of an Indium source was also calculated.

2 Introduction & Theory

2.1 Geiger Counter

A Geiger Counter is a device used to count and measure radioactive particles. As ionised radioactive particles enter the tube, they ionise the Argon gas particles in the tube. These in turn ionise even more particles, causing an avalanche effect. The charge carrying ions then make contact with the anode or cathode, depending on weather a β-particle (*electron*) or an α-particle (*a helium nucleus*) enter the tube respectively. This causes a current to flow through the detector, and a count is registered. Finally the quenching agent stops the avalanche effect, and the system is set up for the next radioactive particle to enter it.

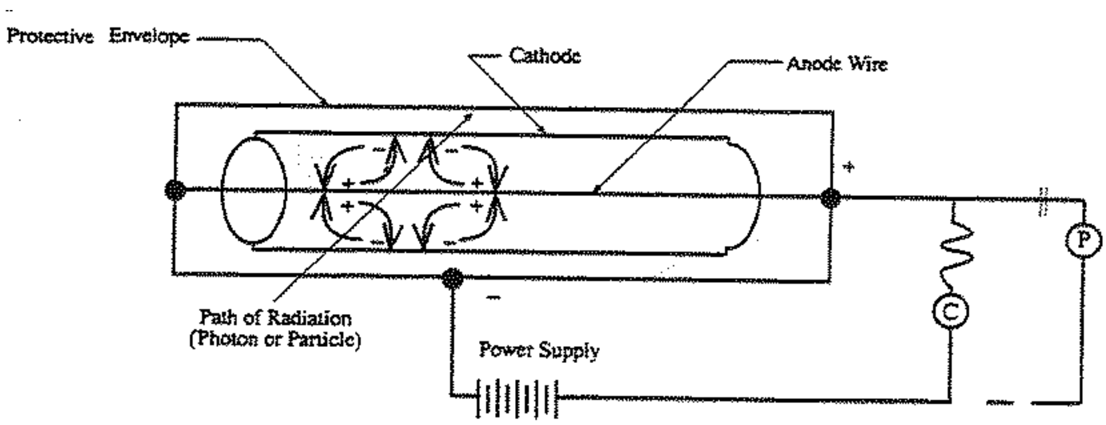

Figure 1: A Geiger Counter

2.2 Background Count

All over the earth there is a small amount of radioactive particles present due to cosmic radiation, the component of rock in the locality, and other such things. This is called the '*background count*' radiation.

2.3 Half Life

Any radioactive source decays spontaneously with time. The *half life* of a radioactive source is defined as the time taken for half the nuclei of a given sample to decay.

2.4 Dead Time

The *dead time* of the counter is the time taken for it to physically count a particle. This means that if another particle enters the tube before the dead time elapses after the previous particle, the second particle will not be counted. This causes inaccuracies in our recordings.

3 Experimental Method

3.1 Half-Life of Neutron Irradiated Indium

The Geiger counter was turned on with no source present. The count for 10 minutes was record. The Background Count Rate was then calculated from this value.

3.2 Half-Life of Indium

The Indium source was placed in the upper slide beneath the Geiger Tube. The count for one minute was taken every five minute interval for two hours. This data was then used to plot a graph of the count rate and the natural log of the count rate of the versus the time respectively. From these graphs we were able to deduce the half life of the Indium.

3.3 Dead Time

Next, the Carbon-14 was placed on the double source slide. One position was covered over with a coin, and the count for a 600s interval. The coin was switched to cover the other position, again leaving only one source registering, and a count was taken. Finally, the coin was removed altogether, and a count was taken for both source positions. The Rate for each of these counts was then calculated and called m_1, m_2 and m respectively.

4 Results

4.1 Background Count

The background Count Rate was calculated to be to be $0.56 \pm 0.07 s^{-1}$.

4.2 Half-Life of Indium

The following is a table of the measurements taken for the counts of the Indium sample

$CountTime \pm 0.3(s)$	$Rate(s^{-1})$	$LnRate$	
1509 ±39	30	25.15 ±0.03	3.22 ±1.29
1367 ±37	330	22.78 ±0.03	3.13 ±0.11
1265 ±36	630	21.08 ±0.03	3.05 ±0.05
1172 ±34	930	19.53 ±0.03	2.97 ±0.03
1120 ±33	1230	18.67 ±0.03	2.93 ±0.03
1090 ±33	1530	18.17 ±0.03	2.90 ±0.02
963 ±31	1830	16.05 ±0.03	2.78 ±0.02

The following graphs were then plotted based on the data

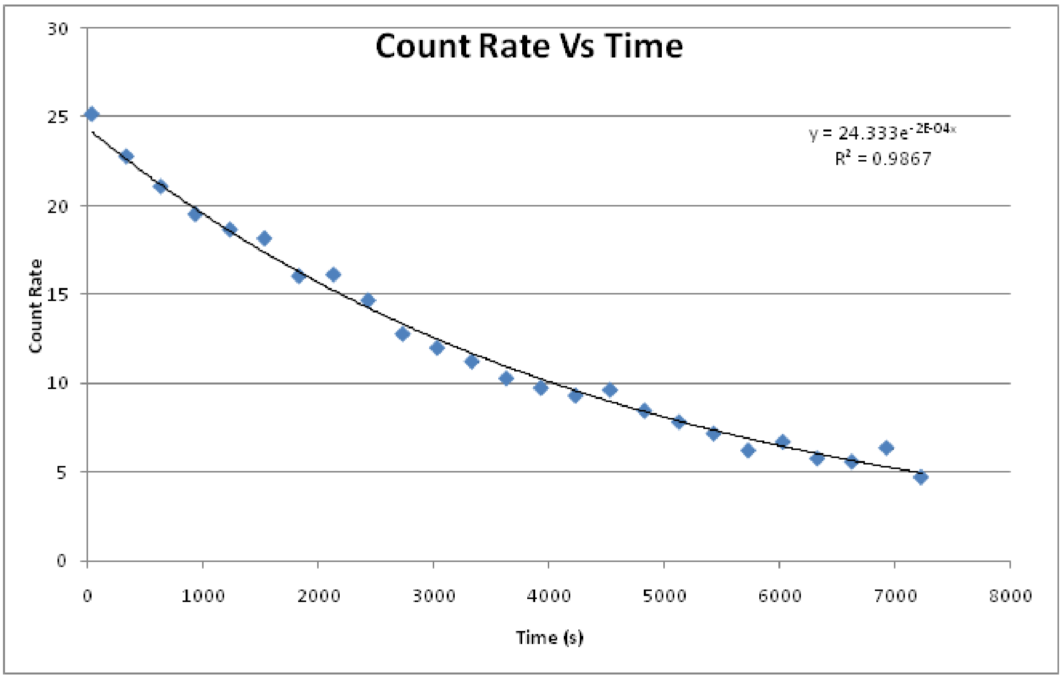

Figure 2:

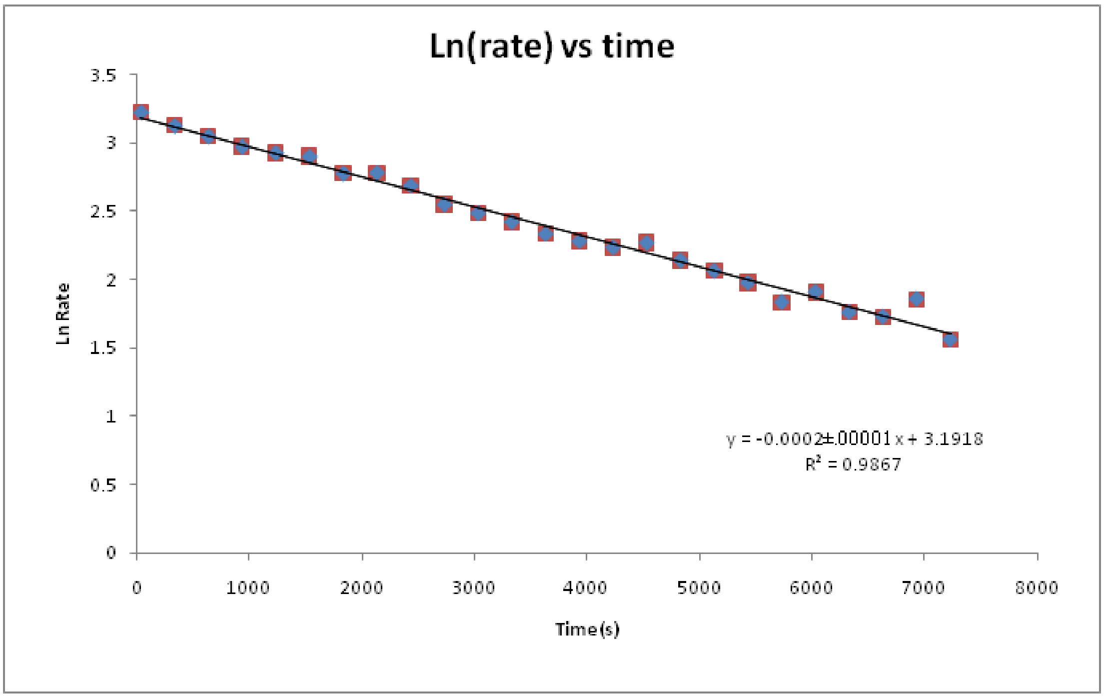

Figure 3:

From these graphs we were able to calculate a value for the Half-life. First a value for λ, the decay constant, of $\lambda = 2 \times 10^{-} \pm 1 \times 10{-}5$ was found from the slope of the graph. With this then the value of the Half-Life was calculated to be $t_{1/2} = 3465 \pm 250s$.

4.3 Dead Time

Using our recorded count rates from above, m_1, m_2 and m, and the following derived expression to relate recorded count rates, the true values n_1, n_2 and n, and the dead time τ

$$\tau^2 - \frac{2}{m}\tau + \frac{m_1 + m_2 - m}{m m_1 m_2} = o$$

Solving this quadratic, the true values for the count rates were found. The following results were obtained

m_1 470	m_2 524	m 807
τ_1 2×10^{-3}	τ_2 4.68×10^{-4}	
n_1 7800	n_2 -10900	n -3100
n'_1 694	n'_2 603	n' 1297

Where the n_i were calculated using τ_1 and the n'_i using τ_2. Clearly this means the first value for τ is incorrect, and we conclude that the dead time is 468ns.

5 Error Analysis

The error in the Counts, the count Rate,the natural log of the count rate, and τ were given by the formula

$$\Delta N = \sqrt{N}$$

$$\Delta R = R\sqrt{\left(\frac{\Delta t}{t}\right)^2 + \left(\frac{\Delta N}{N}\right)^2}$$

$$\Delta \log(\text{Rate}) = \frac{\Delta \text{Rate}}{\text{Rate}}$$

$$\Delta\tau = \sqrt{\left(\frac{\Delta 2/m^2}{2/m}\right) + \left(\frac{\Delta\sqrt{X}}{\sqrt{X}}\right)^2}$$

6 Conclusions

The Proprieties of the Geiger counter and its uses were found, such as investigating the background count of a room, and determining the half-life of a radioactive substance. The Background count was found to be $0.56 \pm 0.07\text{s}^{-1}$. The half-life of the Indium source was found to be $3466 \pm 250\text{s}^{-1}$. And finally the dead time for the Geiger Counter was found to be 468ns.