Artificial Radioculide Half-Life Based On Activation Curve

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***Abstract*— An experiment on the activation properties of an artificial indium foil was conducted at the National Research Tomsk Polytechnic University laboratory. Background particles were first quantified in a gated chamber. A charged indium foil was positioned in the gated chamber, and the released particles were documented as impulses. The mean values of the measurements were determined together with their corresponding errors. A graph of ln A' versus time (t in minutes) was subsequently constructed. The graph's slope was calculated, representing the decay constant. The half-life of the indium foil was subsequently determined. The graph indicates that the average decay constant is 0.0133 min^{-1} and the mean half-life is 52.2 minutes. The inaccuracy in the average decay constant and mean half-life was determined to be 1.77 × 10^{-3} min^{-1} and 6.6 minutes, respectively. The decay curve was graphed, depicting the activity of the indium sample over time, revealing a decrease in activity as time progresses.**

***Keywords*— Half-life, Decay constant, artificial indium foil, particle detector, decay curve, Russian gated chamber.**

I. INTRODUCTION

Radioactive decay, or nuclear decay, is a method that occurs when the central nucleus of an atom that is unstable dissipates energy by producing radiation, such as alpha particles, beta particles, gamma rays, and conversion electrons. A substance that emits radiation naturally is deemed radioactive. [1]

Radioactive decay is a stochastic process at the atomic level, since the theory of quantum physics posits that it is impossible to forecast the exact moment of decay for a specific atom. The probability of a certain atom undergoing decay remains constant, irrespective of its age. The decay rate of a substantial assemblage of atoms may be determined from their observed decay constants or half-lives. This constitutes the foundation of the concept of radiometric dating. The half-lives of radioactive isotopes have no established lower or upper bounds, including a temporal range over 55 orders of magnitude, from virtually instantaneous to significantly beyond the duration of the universe. A radioactive source emits its decay products uniformly in all directions. [2]

Numerous nuclear species exhibit instability and undergo transitions to alternative species by absorbing or producing high-energy particles and photons, including gamma rays. The change in the number of decaying nuclei ΔN at a time period Δt is directly proportional to the current number N of nuclei present. i.e.,

$$N = N_o\, e^{-\lambda t} \quad (1)$$

In order to be charged (excited state), Indium foil was placed in close proximity to a Plutonium (Pu) Beryllium (Be) source overnight in this experiment. Plutonium generates helium particles that interact with Beryllium in accordance with the following equation:

$$^{2}_{4}He + {}^{9}_{4}Be = {}^{12}_{6}C + {}^{1}_{0}n \quad (2)$$

After being released, the neutron interacts with the Indium foil, causing it to enter an excited state.

$$In + {}^{1}_{0}n = {}^{*}\mathrm{In} \quad (3)$$

Particle detectors, including the Russian gated MKS machine, quantify the number of particles emitted per second from a radioactive source and document this measurement as an impulse. The Indium foil was subsequently positioned within a gated chamber (Russian machine), and impulse measurements were recorded at time intervals of 0, 5, 10, 15, 20, 30, 45, and 60 minutes. The initial impulse within the chamber was documented before the measurement of the Indium foil was conducted. The initial measurement is referred to as the background impulse. The experiment was repeated with varying masses of Indium foil, charged over a specified time interval. [3,4]

Objectives

1. To determine the decay of charged indium foil (artificial)
2. To determine the activation characteristics of Indium foil of different masses and
3. Calculate the decay constant and half-life.
4. Plot the activation decay curve.

Organization

The following section outlines the preparation of the remaining article: Section II encompasses work pertinent to

the preceding study. The suggested approach is detailed in Section III, the experimental results are provided in Section IV, the discussion is included in Section V, and the conclusions are found in Section VI.

II. LITERRATURE SURVEY

In most instances, the interaction between thermal neutrons and non-fissionable nuclei leads to the occurrence of radioactive capture (n, γ), which is realised in the following manner:

$$ {}^{A}_{Z}M + {}^{1}_{0}n \rightarrow {}^{A+1}_{Z}M + \Upsilon \quad (4) $$

The accumulation of radioactive atoms in the irradiated sample can be analysed mathematically in the following manner. A thin sample, defined as one where the alteration in the flow of particles passing through it is significantly less than that flow, containing N_{cm} atoms, is positioned within a thermal neutron flux with a density of Φ, $cm^{-2} \cdot s^{-1}$.

Subsequently, within the time interval dt, $\Phi N_{cm}\sigma_a dt$ new active atoms will emerge (where σ_a represents the macroscopic cross section of neutron absorption by a stable nucleus). The formation of active nuclei is accompanied by the occurrence of their decay process. At time t, if there are N active nuclei, then over the interval dt, λNdt of these nuclei will undergo decay, where λ represents the decay constant [4].

There is a simultaneous increase and decrease in the number of active nuclei, hence the following differential equation may be used to find the change in this number over time N(t):

$$ \frac{dN(t)}{dt} = \Phi N_{cm}\sigma_a - \lambda \mathrm{N(t)}, \quad (5) $$

where $\Phi N_{cm}\sigma_a$ – the number of radioactive nuclei formed per unit time.

By integrating equation (2.1) with the initial scenario that at time t=0, N(t)=0, and working under the assumption that at every point during the exposure period, the quantity of active nuclei formed is significantly less than the amount of the stable isotope nuclei, we derive:

$$ N(t) = \frac{\Phi N_{cm}\sigma_a}{\lambda}\left[1 - e^{-\lambda t}\right] = N_{max}[1 - e^{-\lambda t}] \quad (6) $$

Therefore, it can be concluded that as the irradiation time extends (t→∞), the quantity of active nuclei that accumulate in the sample approaches its maximum value.

$$ N_{max} = \frac{\Phi N_{cm}\sigma_a}{\lambda} \quad (7) $$

We may virtually infer that the sample has achieved saturation when the number of radioactive nuclei generated per unit time is equal to the number of decaying nuclei, as long as the irradiation duration is 8 ÷ 10 half-lives. At this point, the difference between N(t) and N_{max} is only 10^{-2} percent [5]. Keeping an eye on how the activity of sample (A) varies over time will allow us to estimate the pace of rise of the number of radioactive atoms:

$$ A = \lambda \mathrm{N} = \lambda N_{max}[1 - e^{-\lambda t}] \quad (8) $$

Denoting λN_{max} as $Amax$ − Activity of sample saturation (at the moment of time $t \rightarrow \infty$), we obtain that the activity of the sample increases according to the exponential law with the same period that the number of radioactive nuclei:

$$ A = A_{max}[1 - e^{-\lambda t}] = A_{max}\left[1 - e^{-\left(\frac{In2}{T_{\frac{1}{2}}}t\right)}\right], \quad (9) $$

Where $T_{\frac{1}{2}} = \frac{In\,2}{\lambda}$ is the half-life, i.e. the time during which the activity of the sample is reduced by half.

Suppose that at the moment of time $t=t_0$ the sample irradiation by neutrons has stopped. Radioactive nuclei accumulated by this moment, will decay according to the exponential law:

$$ N = N_o e^{-\lambda t} \quad (10) $$

where N_o – number of radioactive nuclei accumulated by this moment of time t_o;
t – time since the end of irradiation; λ – decay constant.

Change in the activity A of the sample in time is determined by the relation:

$$ A = \frac{dN}{dt} = \lambda \mathrm{N} = \lambda \mathrm{N}_o e^{-\lambda t} \quad (11) $$

Denoting $\lambda \mathrm{N}_o$ as A_o – activity of the sample after irradiation (at the moment of time $t=t0$), we obtain that the activity of the sample decreases according to the exponential law with the same period that the number of radioactive nuclei:

$$ A = A_o e^{-\lambda t} = A_o e^{-\left(\frac{In2}{T_{\frac{1}{2}}}t\right)} \quad (12) $$

Fig. 1 illustrates the increase in activity of the sample during irradiation and its subsequent decrease during de-excitation.

The amount of activity of the material being studied can be scientifically tracked as it corresponds to the number of particles emitted per unit time, which can be detected by counters or other devices [6]. For instance, consider a scenario where the source of β^- particles is positioned near a beta counter. The activity of the test sample is directly proportional to the number of pulses recorded by a counter per unit time.

$$ \text{At decay - } A(t) = \frac{n(t)}{\omega} = \frac{n_o}{\omega} e^{-\lambda t} = A_o e^{-\lambda t}, \quad (13) $$

At activation –

$$ A(t) = \frac{n(t)}{\omega} = \frac{n_{max}}{\omega}[1 - e^{-\lambda t}] = A_{max}[1 - e^{-\lambda t}], \quad (14) $$

Where $n(t)$ – the number of pulses registered by a counter per unit time, at the moment of time t (count rate);
n_o – count rate at the initial moment of time $t = t_o$;

n_{max} – count rate at the final moment of time $t \to \infty$ under experimental conditions it is necessary to satisfy the condition $t > 10T_{\frac{1}{2}}$;

relations $A_o = \frac{n_o}{\omega}$ and $A_{max} = \frac{n_{max}}{\omega}$ – sample activity at the initial and final moment of time, respectively; ω = 0.3 – mean probability of β^-—particle registration.

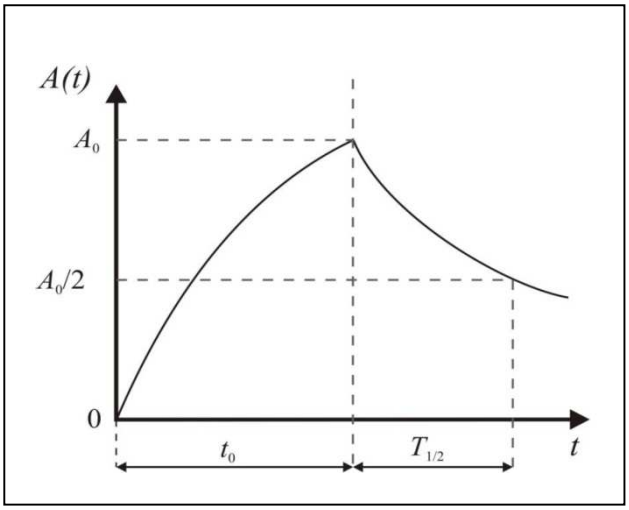

Fig. 1. Change in the sample activity in time during its irradiation and radioactive decay

A. Introduction of ω

The following factors contribute to its occurrence:

- When an active sample is located outside of the counter's sensitive volume, the counter will only detect a portion of the particles. Particle registration percentages decrease when the solid angle between the radiation source and the counter decreases.
- Secondly, some of the particles travelling in the opposite direction might be absorbed by the source, the air flowing towards the counter, or even the counter's walls.
- Lastly, some particles that have gone through the counter are not recorded because of the dead time (also known as insensitive time or resolution time) of devices, which detect radiation.

The effect of these variables on the measured amount could vary among trials. All three of these considerations are crucial, for instance, for calculating the sample's absolute activity [7].

For the sake of argument, let's say that a counting device is alternated at time t for time dt. The count rate may be expected to remain constant throughout measurement time dt if the time required to measure is much less than the half-life of the test nuclide. We can then create a time series graph showing the sample's activity levels rising or falling based on our knowledge of the registration efficiency ω and count rate [8]. If we take the logarithm of either equation (13) or (14), we can get the test nuclide's decay constant:

At decay – $= \frac{InA_o - InA(t)}{t} = \frac{Inn_o - In\, n(t)}{t}$, (15)

At activation –

$$\lambda = \frac{InA_{max} - In[A_{max} - A(t)]}{t} = \frac{Inn_{max} - In\,[n_{max} - n(t)]}{t} \quad (16)$$

Hence, plotting value $Inn(t)$ or $In\,[n_{max} - n(t)]$ on a logarithmic graph, we obtain a straight line, the slope of which is equal to λ. After determination of the slope, a half-life is calculated:

$$T_{\frac{1}{2}} = \frac{In2}{\lambda} = \frac{0.693}{\lambda} \quad (17)$$

It is usual practice to use a differential approach when analysing a decay or activation curve [9].

The following rule governs the decay of radioactive nuclei collected in a sample that is a combination of two isotopes:

For 1st Isotope - $N_1 = N_{01}e^{-\lambda_1 t}$,
For 2nd Isotope - $N_2 = N_{02}e^{-\lambda_2 t}$,

For total number of radioactive nuclei –

$$N = N_1 + N_2 = N_{01}e^{-\lambda_1 t} + N_{02}e^{-\lambda_2 t}, \quad (18)$$

N_{01} and N_{02} - represent the quantities of radioactive nuclei accumulated at time t0 for the first and second isotopes, respectively; λ_1 and λ_2 denote the decay constants for the first and second isotopes, respectively; t indicates the duration since the conclusion of irradiation [10,11].

The sample's activity will be assessed based on the established relationship:

$$A = A_1 + A_2 = \frac{dN_1}{dt} + \frac{dN_2}{dt} = \lambda_1 + \lambda_2 = \lambda_1 N_{01}e^{-\lambda_1 t} + \lambda_2 N_{02}e^{-\lambda_2 t} \quad (19)$$

A_1 and A_2 represent the contributions to the sample's activity from the first and second isotopes, respectively. If the half-life of the first isotope is significantly longer than that of the second isotope ($T_{\frac{1}{2}}^1 \gg T_{\frac{1}{2}}^2$),), then after a duration $t \gg 10T_{\frac{1}{2}}^2$,, it can be assumed that the activity of the sample is predominantly influenced by the decay of the first isotope.

$$A = A_1 = \frac{dN_1}{dt} = \lambda_1 N_1 = \lambda_1 N'_{01}e^{-\lambda_1 t} = A'_{01}e^{-\lambda_1 t} \quad (20)$$

where – contribution to the activity of the sample of the 1st isotope at the moment of time $t_{01} = 10T_{\frac{1}{2}}^2$, N'_{01} number of radioactive nuclei of the 1st isotope at the moment of time t_{01}.

Taking the logarithm of equation (20), we can determine the decay constant of the 1st isotope:

$$\lambda_1 = \frac{InA_{01} - InA(t)}{t} = \frac{Inn_{01} - In\, n(t)}{t}, \quad (21)$$

where n_{01} – contribution of the 1st isotope to the count rate at the moment of time $t_{01} = 10T_{\frac{1}{2}}^2$.

As a result, we can determine the contribution of the 1st isotope to the sample activity at any moment of time, and we can determine a decay constant for the 2nd isotope from eqn (14):

$$A(t) = A_1(t) + A_2(t) = A_{01}e^{-\lambda_1 t} + A_{02}e^{-\lambda_2 t}, \quad (22)$$

where A_{01} and A_{02} – contribution of the 1st and 2nd isotope to the sample activity at the end of irradiation t_0.

$$A_2(t) = A_{02}e^{-\lambda_2 t} = A(t) - A_1(t) \quad (23)$$

Taking the logarithm of eqn. (23), we obtain:

$$\lambda_2 = \frac{InA_{02} - InA_1(t)}{t} = \frac{Inn_{02} - In\, n_1(t)}{t}, \quad (24)$$

where n_{o2} – contribution of the 2nd isotope to the count rate at the moment of time t_0; $n_1(t)$ – contribution of the 1st isotope to the count rate at the moment of time t.

Using expression (24) we can determine the half-life for the 1st and 2nd isotopes.

Description of the experimental installation

Beta-activity of the sample is measured by standard computational devices. Counter of ionizing particles converts ionization from the passing of a charged particle, arising in its volume, into electrical pulses. The pulses from the counter output are fed to the former, which converts them to the standard in amplitude and duration, required for the operation of the scaling device. If necessary, the formation of pulses is preceded by additional amplification. As beta-counter a scintillation counter is used [12,13].

As a test sample for laboratory work: decay and activation curve indium plate is used. Table I contains isotopic composition of natural indium and products of (n,ϒ)–reaction, occurring during irradiation of natural isotopes with thermal neutrons [14,15].

TABLE I. NUCLEAR CHARACTERISTICS OF INDIUM ACTIVATION DETECTORS

Isotopic composition of natural indium	Isotope content, %	Activation cross section, barns	Radioactive product	Half-life of radioactive product
$^{113}_{49}In$	4.23	58±12	$^{114m}_{49}In$	49 days
			$^{114}_{49}In$	72 c
$^{115}_{49}In$	95.77	197±15	$^{116m}_{49}In$	54 min
			$^{116}_{49}In$	13 c

Note: Activation cross-sections are given for neutrons with velocities 2000 m/s.

III. METHODOLOGY

The precautionary guidelines were reviewed. This signifies an emphasis on comprehending safety protocols during laboratory work. This background underscores the need of safety in laboratory settings. Investigations were conducted with authorization and this demonstrates compliance with procedure and oversight. This document outlines the experimental techniques undertaken.

The counting device's operability in test mode was confirmed. The background of the counting device was measured three times. The duration of a single measurement (tdet) is 30 seconds. The sample from the neutron source container was exposed for 30 seconds without measurement.

The dependence of the count rate on time (t) was eliminated. Measurements were conducted at each time point (t). The duration of one measurement (t, min) was 30 seconds. The results obtained (n) are documented in the table II.

The background measurement of the scaling device following the repeated measurements.

Processing of experimental results

Mean background of the scaling device and its measurement error was calculated using the relation:

$$\bar{n}_\phi = \frac{1}{I}\sum_{i=1}^{I} n_{\phi_i}\ ;\ \sigma_\phi = \sqrt{\frac{1}{I(I-1)}\sum_{i=1}^{I}(\bar{n}_\phi - n_{\phi_i})^2} \quad (25)$$

Where, i represents the number of measurements taken (3 in this case); I – number of background measurements, in this case it is equal to 3; n_{Φ_i} – count rate of background in i-measurement.

To determine the mean value of count rate at the moment of time t, caused only by Indium sample activity (N), i.e., to eliminate background and to evaluate its error (σ_N) from all obtained gauging, using relations N.

$$\bar{n} = \frac{1}{I}\sum_{i=1}^{I} n_i\ ;\ \sigma_n = \sqrt{\frac{1}{I(I-1)}\sum_{i=1}^{I}(\bar{n} - n_i)^2} \quad (26)$$

where i – measurement number at the moment of time t and in this case, it can take the values 1, 2, 3; I –number of measurements at the moment of time t and in this case, it is equal to 3; n_i – count rate in i-measurement

To determine the mean value of count rate ($\bar{n}$) and its measurement error (σ_N) for all the moments of time t by the relations:

$$\overline{\ln A'} = \ln\bar{A}';\ \sigma_{\ln} = \frac{\sigma_{A'}}{A'} \quad (27)$$

To construct a graph of the dependence of sample activity on time on the semilogarithmic scale,($\overline{InA'} = f(t)$). For this purpose, experimental values ln A with confidence intervals is plotted on a graph, within which two straight lines are constructed.

Since a decay constant is determined according to the slope of these lines, it is necessary to construct them in

two extreme slope angle positions ("shallow" - 1 and "sharp" - 2 lines in fig. 2.

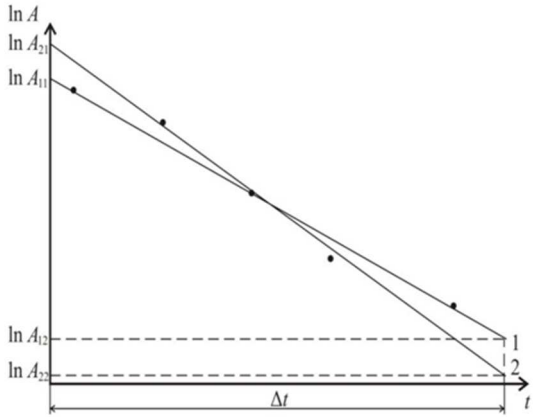

Fig. 2. The processing of the relationship of sample activity with time, presented on a semilogarithmic scale.

If the values of confidence intervals are low for the construction of straight lines($\sigma_{ln} << \overline{\ln A'}$), then the lines are constructed in such a way, that the points above and below the line balance each other (fig. 3).

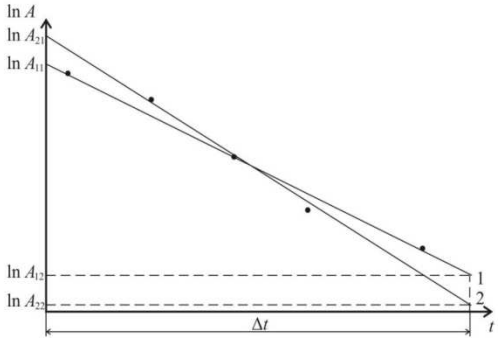

Fig. 3. An example of processing of dependence of sample activity on time on a semilogarithmic scale

IV. EXPERIMENTAL FINDINGS

To calculate the mean background of a scaling device (n_ϕ) and its measurement error (σ_ϕ) by the relations;

$$n_\phi = \frac{1}{I}\sum_{i=1}^{I} n_{\phi i}$$

$n_\phi = \frac{0{,}24+0{,}26+0{,}29}{3}$ = 0.26 pulse/s

The mean background of scaling device = 0.26 pulse/s

$$\sigma_\phi = \sqrt{\frac{1}{I(I-1)}\sum_{i=1}^{I}(n_\phi - n_{\phi i})^2}$$

$$\sigma_\phi = \sqrt{\frac{1}{3(3-1)}(0.24-0.26)^2 + (0.26-0.26)^2 + (0.29-0.26)^2}$$

$$\sigma_\phi = 0.05 \text{ pulse/s}$$

Therefore, for background measurement error = 0.05 pulse/s

To determine the mean value of count rate ($\bar{n}$) and its measurement error σ_n for all the moments of time t (t=0, 10,20, 30,45 and 60 min) by the relation;

$$\bar{n} = \frac{1}{I}\sum_{i=1}^{I} \bar{n}_i$$

For t=0; 1= 22.6, 2=21.4, 3=20.4 pulse/s where I = 3

$$\bar{n} = \frac{1}{I}\sum_{i=1}^{I} \bar{n}_i$$

$\bar{n} = \frac{22.6+21.4+20.4}{3}$ = 21.5 pulse/s

The mean value count rate $\bar{n} = 21.5$ pulse/s

$$\sigma_n = \sqrt{\frac{1}{I(I-1)}\sum_{i=1}^{I}\overline{(n-\bar{n}_i)^2}}$$

$$\sigma_n = \sqrt{\frac{1}{3(3-1)}(22.6-21.5)^2 + (21.4-21.5)^2 + (20.4-21.5)^2}$$

$$\sigma_n = 0.94 \text{ pulse/s}$$

The error in measurement $\sigma_n = 0.94$ pulse/s

Therefore, the mean of count rate and its error $\bar{n}$ = 21.5 ± 0.94 pulse/s

To determine the mean value of count rate at the moment of time *t*, caused only by indium sample (N):

$$N = \bar{n} - \bar{n}_\phi$$

From reading above, N = 21.5 – 0.26 = 21.24 pulse/s
The total error:

$$\sigma_N = \sqrt{{\sigma_n}^2 + {\sigma_\phi}^2}$$

$$\sigma_N = \sqrt{0.94^2 + 0.05^2}$$

$$\sigma_N = 0.94 \text{ pulse/s}$$

Therefore, the value of mean count rate caused only by indium sample activity (N) =21.24 ± 0.94 pulse/s

To determine the mean value of the indium sample and its error using relations:

$$n_\phi = \frac{1}{I}\sum_{i=1}^{I} n_{\phi i}$$

Activity at t= 0 can be determined through

$$\overline{A} = \frac{\overline{N}}{\omega}$$

$$\sigma_A = \frac{\sigma_N}{\omega}$$

where ω = 0.3

$$\bar{A} = \frac{21.24}{0.3} = 70.8 \text{ decay/s}$$

$$\sigma_A = \frac{0.94}{0.3} = 3.13 \text{ decay /s}$$

Therefore, activity A = 70.8 ± 3.13 decays/s

Ln values of activity ln A and of its error were determined from (t=0, 10,20, 30,45 and 60 min) respectively

For t = 0s;

Ln(A) = ln(70.8) = 4.26
Ln(σ_A)= ln (3.13) = 1.14

Therefore, ln (A) can be written as 4.26 ± 1.14

The graph of ln(A) against time (min)

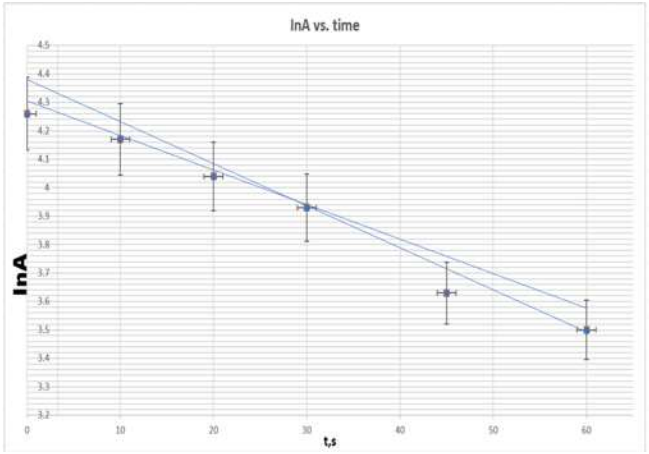

Fig. 4. A graph of ln(A) against time, minutes

a. From the graph above the values of decay constants are determined by;

$$\lambda_1 = \frac{ln\, A_{11} - ln\, A_{12}}{\Delta t} = \frac{4.3-3.60}{60} = 0.01167 \text{ min}^{-1}$$
$$\lambda_2 = \frac{ln\, A_{21} - ln\, A_{22}}{\Delta t} = \frac{4.39-3.49}{60} = 0.015\ min^{-1}$$

b. The average value of decay constant and its error are determined by;

$$\overline{\lambda} = \frac{\lambda_1+\lambda_2}{2} = 0.0133\ min^{-1}$$

$$\sigma_\lambda = \sqrt{\frac{(\bar{\lambda}-\lambda_1)^2+(\bar{\lambda}-\lambda_2)^2}{2}} = 1.7 \text{ x}10^{-3}\text{min}^{-1}$$

c. The average value of half-life and its error are determined by;

$$\overline{T} = \frac{ln\, 2}{\bar{\lambda}} = 52.12 \text{ min}$$

$$\sigma_T = \frac{ln\, 2 \cdot \sigma_\lambda}{\lambda^2} = 6.66 \text{ min}$$

d. By using A_0=70.8 dec/s. was used to calculate value of activity at time t by using:

$$A(t) = \bar{A}_0 \exp(-\bar{\lambda} t)$$

Time (min)	0	10	20	30	45	60
A(t) dec/s	70.8	61.98	54.3	47.5	38.9	31.9

The data obtained were used to plot the decay curve below

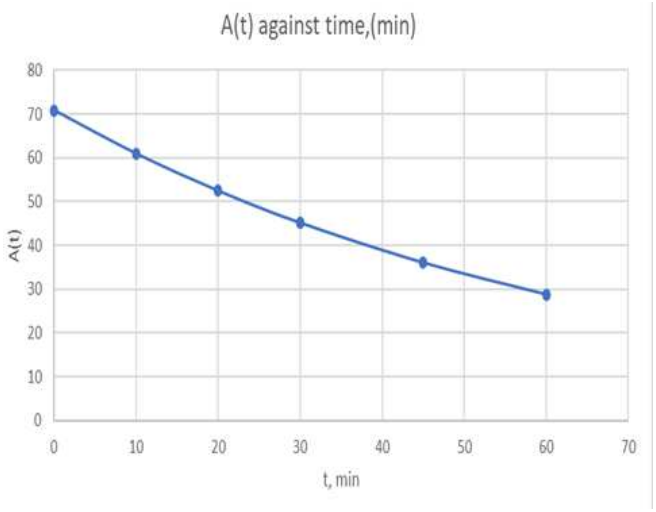

Fig. 5. A decay curve

From the graph above it can be observed that as the time increases the activity decreases, this is because radioactive decay causes reduction in number of unstable nuclei in a sample which reduces count rate.

V. Discussion

The excited Indium foil was then placed into a gated chamber and impulse was recorded on time intervals of 0, 5, 10, 15, 20, 30, 45, 60 minutes. Initial impulse within the chamber was recorded prior to the measurement of the indium foil. The initial measurement was called background impulse. The experiment was again conducted for different masses of Indium foil when charged in a particular time interval.

The mean background of a scaling device (n_ϕ) and its measurement error (σ_ϕ) were found to be 0.26 pulse/s and 0.05 pulse/s. The determine the mean value of count rate ($\bar{n}$) and its measurement error σ_n for all the moments of time t was found to be 21.5 pulse/s and 0.94 pulses/s. The mean value of the indium sample and its error were found to be 70.8 decay/s and 3.13 decay/s respectively.

TABLE II. THE RECORDED MEASUREMENTS

t, min	n, pulse/s	$\bar{n} \pm \sigma_n$, pulse/s	$\bar{N} \pm \sigma_N$, pulse/s	$\bar{A} \pm \sigma_A$, decay/s	$\overline{lnA} \pm \sigma_{ln}$
0	22.6 21.4 20.4	21.5± 0.94	21.2± 0.697	70.8 ±3.13	4.26 ± 1.14
10	20.2 19.6 19.3	19.7± 0.048	19.26± 0062	64.19± 0.2	4.17± 0.0032
20	18.8 17.1 16.4	17.42± 0.156	17.02± 0.16	56.74± 0.53	4.04± 0.0094
30	16.4 16.4 16.3	16.3± 0.395	15.9± 0.4	53± 1.32	3.97± 0.025
45	13.4 12.9 9.1	11.72± 0.496	11.32± 0.5	37.74± 1.66	3.63± 0.0439
60	11.3	10.34± 0.487	9.94± 0.5	33.15± 1.63	3.5± 0.0492

The decay constant was calculated to be 0.0133 min^{-1} from the graph the LnA against time and thereafter, the half-life of the artificial radionuclide was found to be 52.21 minutes. The values of the activity were calculated at different times using the activity equation. A graph of Activity versus time was then plotted as a decay curve. It was observed that as the time increases the activity decreases.

VI. Conclusion

From this experiment, the value of decay constant was determined to be 0.0133min^{-1}, the half-life of the Indium sample was calculated to be $T_{1/2}$= 52.21 minutes and its error approximately equal to 6.6 minutes. Based on the given Indium sample $^{116}_{49}I$ its half-life is 54 minutes; there is a very little difference between the experimental value and the actual value which is corrected by the value of its calculated error. The activity of a sample decreases as the time increases.

References

[1] F. Guerra, M. Leone, & N. Robotti, “The discovery of artificial radioactivity. Physics in Perspective, 14(1), pp. 33–58, 2012.

[2] P. B. Moon, “Artificial radioactivity,” Cambridge University Press, 2014.

[3] A. Beiser, “Concepts of modern physics”, McGraw-Hill, 2021.

[4] J. Landa, & S. Palágyi, “Simple method for calculating time dependence of individual radionuclide activities in decay series,” Open Chemistry, 5(3), pp. 868–879, 2007.

[5] D. Mubita, E. Mubanga, & I. Ushakov, "Optimized chromatographic production of high-purity 177Lu radionuclide at IRT-T research reactor for nuclear medicine applications," Hacked By Aptisme, 5(2), pp.25-56, 2024.

[6] P.W. Atkins, & J. De Paula, “Aktins’ Physical chemistry for the Life sciences,”, 2011.

[7] J. Basdevant, J. Rich, & M. Spiro, “Fundamentals in Nuclear Physics: From Nuclear Structure to Cosmology,” Springer Science & Business Media, 20005.

[8] R. D. Braun, “Basic Chemistry (Zumdahl, Steven S.),” Journal of Chemical Education, 69(2), 1992.

[9] T. E. Brown, J. H. E. LeMay, B. E. Bursten, , C. J. Murphy, P.M. Woodward, M.W. Stoltzfus, “Chemistry: the central science, Pearson Higher Education AU, 2013.

[10] D. J. Schlyer, P. Van den Winkel, T.J. Ruth, M.M. Vora, M. Pillai, & M. Haji-Saeid, "Cyclotron produced radionuclides: Principles and practice," IAEA Technical Reports Series, p. 465, 2008.

[11] H. M. Dung, M. Blaauw, D. Beasley, & M. D. C. Freitas, “Development of the k 0-based cyclic neutron activation analysis for short-lived radionuclides,” Journal of Radioanalytical and Nuclear Chemistry, 291(2), pp. 485–492, 2011.

[12] P. K. Hopke, “Radon and its decay products: Occurrence, Properties, and Health Effects,” Americal Chemical Society, 1987.

[13] Iaea, “Alternative Radionuclide Production with a Cyclotron,” International Atomic Energy Agency, 2021.

[14] C. E. Junge, “Air chemistry and radioactivity,” In International geophysics/International geophysics series, 1963.

[15] M. F. L’Annunziata, “Radioactivity: Introduction and History,” From the Quantum to Quarks. Elsevier, 2016.

[16] S. Luo, “Nuclear science and Technology: Isotopes and Radiation,” Springer Nature, 2023.

[17] O. E Samad, R. Baydoun, B. Nsouli, & T. Darwish, “Determination of natural and artificial radioactivity in soil at North Lebanon province,” Journal of Environmental Radioactivity, 125, pp. 36–39, 2013.

[18] A. U. Scientific, “Application of radioactive isotopes in microbiology: A portion of the Proceedings of the All-Union Scientific and Technical Conference on the Application of Radioactive Isotopes,” Springer Science & Business Media, 2013.

[19] H. Taskin, and Karavus, MELDA and Ay, P and Topuzoglu, AHMET and Hidiroglu, SEYHAN and Karahan, G, “ Radionuclide concentrations in soil and lifetime cancer risk due to gamma radioactivity in Kirklareli, Turkey. Journal of environmental radioactivity, 100(1), pp. 49-53, 2009.

[20] J. Wain, “Introductory Nuclear Physics,” In Synthesis lectures on engineering, science, and technology, pp. 1–5, 2024.

[21] D. P. Wells, C.R. Segebade, F. D. McDaniel, & B. L. Doyle, “ An overview of activation analysis techniques and applications,” AIP Conference Proceedings, pp. 452–457, 2011.

[22] M. Wurm, J. F. Beacom, L. B. Bezrukov, D. Bick, J. Blümer, S. Choubey, ... & J. Winter, "The next-generation liquid-scintillator neutrino observatory LENA," Astroparticle Physics, 35(11), pp. 685-732, 2012.

[23] https://doi.org/10.1016/j.astropartphys.2012

[24] https://prezi.com/mlgxm2kx0rsh/history-of-the-planet/

[25] https://www.doubtnut.com/qna/643189307