(NU3-6) Fundamental law of radioactive decay

Aim of experiment

Determination of the characteristic decay law for a short-lived radioactive source and its half life time.

Apparatus

GM tube counting station consists of GM counter – radioactive source- source holder- stop watch, source cabinet made of thick lead.

Theory of experiment

Each nucleus has a fixed probability of decaying per unit time. Nothing affects this probability (e.g., temperature, pressure, bonding environment, etc.) [Exception: very high pressure promotes electron capture slightly]

This is equivalent to saying that averaged over a large enough number of atoms the number of decays per unit time is proportional to the number of atoms present. Therefore in a closed system:

$$\frac{dN}{dt} \alpha \quad N(t)$$

$$\frac{dN}{dt} = -\lambda N(t) = A(t)$$

where A is the activity of the source after elapsed time, d.

and N = number of parent nuclei at time t and it is proportional to the activity A.

λ = decay constant = probability of decay per unit time. λ may have the units time^{-1} (e.g. s^{-1}, d^{-1}, m^{-1}, y^{-1})

To get time history of number of parent nuclei, integration of the above equation yields:

$$N(t) = N_0 e^{-\lambda t}$$

N_o = initial number of parent nuclei at time *t = 0.*

At t= $T_{1/2}$, the half-life; the time it takes for half the nuclei to decay - i.e. for activity, A_0, to decrease to $A_0/2$ is given by

$$T_{1/2} = \frac{Ln2}{\lambda}$$

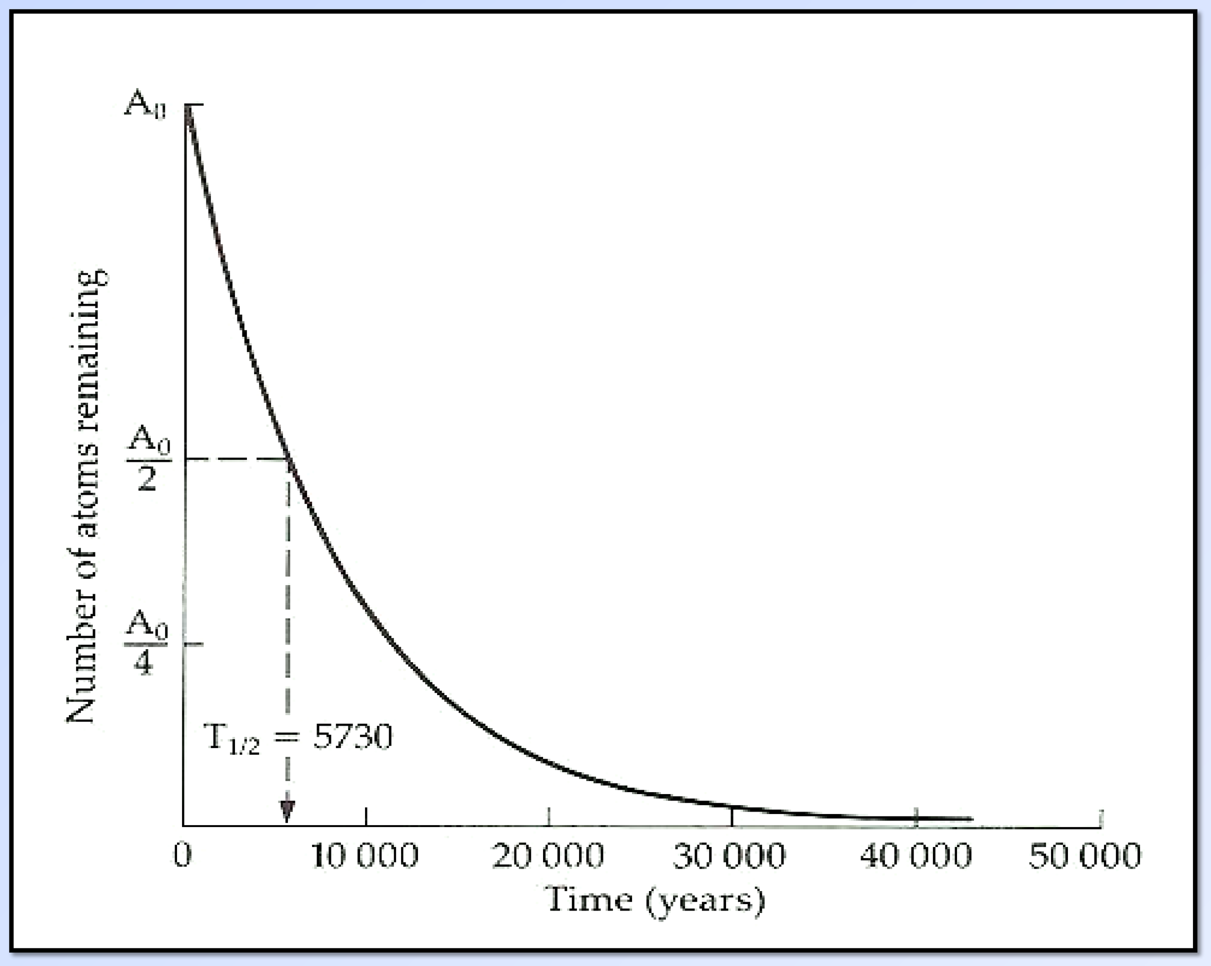

Figure 1 represents the relation between $A=\lambda N$ and time of decay.

At $t=0$ $_{No=Ao}\lambda$, and at $t=T_{1/2}$, $N(T_{1/2})=A_o/2\lambda$.

One can obtain the half-life time and the decay constant of the decaying nucleus. If one plots the relation between *Ln (N)* and the time of decay, ***t,*** a straight line with negative slope is obtained, from which λ is obtained.

$$Ln(N) = Ln(N_0) - \lambda t$$

Procedure

1. Set up the electronics as shown in *Figure 2.*
2. Place a radioactive source on a shelf of the GM stand at a suitable distance.
3. Switch on the power supply and let it warm for few minutes, then set the applied voltage at the tube operating voltage, V_{op}
4. Set the timer on 1 min and measure the background reading, N_{bg} *c/min.*
5. Start count, then start stop watch, t=0 min, and record the corresponding number of counts, *N` c/min.*
6. For successive elapsed times, suitable for the source lifetime, record number of counts per minute in a table.
7. Draw the relation between *Ln(N c/min)* and the elapsed time, *t.*
8. Draw the best line and find the slope, which equals the source disintegration constant, λ.

Results

N_{bg}= c/min

Time, t	*N` c/min*	*N = N`- N_{bg} c/min*	*Ln (N ± √N)*

λ=

Figure 2. A schematic diagram of Geiger counting system

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