Radioactive decay

The decay of any nucleus of radioactive elements (natural and artificial) occurs automatically and means that Radioactive decay is a statistical process, which means that all nuclei are un dissolved, as they have the same probability(λ) to decay in the next second where (λ) it is called the decay constant .

According to the statistical theory during a time(dt) of its amount the probability of decay for each nucleus is equal((λdt)

If we assume that there are (N) of decay nuclei in time (t)then the number of nuclei(dN) that will decay in the period(t) and(t+dt)

is equal :

$$-dN \propto N\,dt$$

$$dN = -\lambda N\,dt \quad \ldots\ldots\ldots\ldots (1$$

الإشارة السالبة تشير إلى نقصان العدد N بمرور الزمن .

$$dN/N = -\lambda\,dt \quad \ldots\ldots\ldots\ldots (2$$

وبتكامل طرفي المعادلة نحصل

$$\int_{N_o}^{N} \frac{dN}{N} = \int -\lambda\,dt \quad \ldots\ldots\ldots\ldots (3$$

حيث (N_o) عدد النوى الاصلية او الابتدائية

$$\ln N - \ln N_o = -\lambda t \quad \ldots\ldots\ldots\ldots (4$$

$$\ln (N/N_o) = -\lambda t$$

$$\therefore\ N = N_o\, e^{-\lambda t} \quad \ldots\ldots\ldots\ldots (5$$

تعطينا المعادلة ($N= N_o e^{-\lambda t}$) عدد النوى غير المنحلة (N) عند اللحظة (t) بدلالة ثابت الانحلال (λ) وعدد النوى الأصلية (N_o) الموجودة عند الزمن (t=0)

$$N = m N_A / A \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots(6$$

حيث :

N : عدد النوى

m : الكتلة

N_A : عدد افوكادرو ($6.022 \times 10^{23}\ mol^{-1}$)

M : الوزن الجزيئي

A : العدد الكتلي ويمكن الاستعاضة عنه بالوزن الجزيئي

$$N^{*} = \rho \ N_A / A \ \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(7$$

$$m = m_o \ e^{-\lambda t} \ \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(8$$

حيث

N^{*} : عدد النوى لوحدة الحجم

ρ : الكثافة

m :- الكتلة الحالية (غير المنحلة)

m_o :- الكتلة الأصلية (قبل الانحلال)

Radiation activity (A)

$$A = \left| \frac{dN}{dt} \right|$$

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

$$A_o = \lambda N_o$$

$$A = A_0 e^{-\lambda t}$$

A_0:The origin activity

A: activity after a time(t)

The unit of radiation activity

1-Disintegration/sec (dps)

2-**Curie or(Ci)**: The amount and value of radioactivity of one gram of radium per second

1 Ci = 3.7×10^{10} (dis /sec) or (dps)

3- Rutherford (rd)

rd = 10^6 dis/sec = 10^6 dps

4- Becquerel

Bq = 1 dps

* **(Specific Radiation Activity) (SA):** The number of Curie or Becquerel per unit mass or volume of radioactive material

(SA) = A / m = A /V

وحداتها:

(Ci /g) or (Bq / kg)

Half-life

It is the time required to dissolve half of the number of atoms present at the beginning of radiation for a given substance, that is to say:

($t=t_{1/2}$)

$$N = N_o/2$$

$$\therefore N_o/2 = N_o\ e^{-\lambda t1/2}$$

$$\therefore \tfrac{1}{2} = e^{-\lambda t1/2} \quad , \quad \ln(1/2) = -\lambda t_{1/2} \quad , \quad -0.693 = -\lambda t_{1/2}$$

$$\therefore t_{\frac{1}{2}} = \frac{0.693}{\lambda}$$

It is clear that after the period of time $t_{1/2}$, half of the number of atoms are present at the beginning of the radiation, and after the passage of a time period $2t_{1/2}$, a quarter of the number of atoms at the beginning of the radiation remains and so the average lifespan of the radioactive isotope is known as:

$$T = \frac{1}{\lambda}$$

Mean life time: It is the average time during which the nuclei remain without radioactive decay

$$T = \frac{1}{\lambda} = t_{1/2}/0.693 = 1.443\ t_{1/2}$$

Exa. Find the time needed to decrease mass 22_{Na} from (5mg to 1mg), knowing that the half-life for22_{Na} is (2.6)years

Solu:

$$m = m_o e^{-\lambda t} \text{............}(1)$$

$$\frac{m}{m_o} = e^{-\lambda t}$$

$$\ln\frac{m_o}{m} = \lambda t \text{.............}(2)$$

$$t = \frac{1}{\lambda}\ln\frac{m_o}{m} \text{............}(3)$$

$$\because \lambda = \frac{\ln 2}{t_{\frac{1}{2}}}$$

λ = o.693/2.6 =0.2665 y^{-1}

$$t = \frac{1}{0.2665\ y^{-1}}\ln\frac{5\ mg}{1\ mg}$$

t =6.039 year