Radioactive Decay

The alpha beta gamma rays emission process are not an instantaneous process. Hence for various elements the decay time is different and the Radioactive decay follows certain laws. At a particular pressure and temperature in Radioactive Isotopes the chemical and physical properties have no effect on the Decay process.

Law : small amount of disintegration of the isotope in a small period is directly proportional to the total number of radioactive nuclei and proportionality constants.

Number of radioactive nuclei present at any time t is N

Initial number of radioactive nuclei N_o

proportionality constant (Radioactive decay constant or disintegration constant) λ lambda

Law equation becomes $\Delta N = -\lambda N \lambda t$

$$dN/dt = -\lambda N$$

- -Sign represent during decay number of nuclei in decreasing

Integrating $\int_{N0}^{N} dN/N = -\lambda \int_0^t dt$

Taking log both side

$\log_e N - \log_e N_0 = -\lambda t$ or $\log \frac{N}{N0} = -\lambda t$

$\frac{N}{N0} = e^{-\lambda t}$ or $N = N_0 e^{-\lambda t}$

$\frac{dN}{dt} = -\lambda N = -\lambda N_0 e^{-\lambda t}$ This reveals that decay scheme follows the exponential law

Intensity of emission is termed activity directly depend on the rate of disintegration of the element

$$A = k\left[-\frac{dN}{dt}\right] = k\lambda N = k\lambda N_0 e^{-\lambda t} = A_1 e^{-\lambda t}$$

A = activity at time t

A_1 = initial activity

k = Deduction coefficient

$$A = A_1 e^{-\lambda t}$$

HALF LIFE

Half-life is the rate of decay of radioactive isotopes. The half life is time required for half the parent nuclei to decay(disintegrate)

Putting the value $N = N_0/2$ and $t = t_{1/2}$ in equation $A = A_1 e^{-\lambda t}$

$$N_0/2 = N_0\ e^{-\lambda}\ t_{1/2} \quad \text{therefore} \quad e^{-\lambda}\ t_{1/2} = \frac{1}{2}$$

Therefore $\lambda\ t_{1/2} = \log_e 2 = 0.693$ There fore $t_{1/2} = \frac{0.693}{\lambda}$

Here $t_{1/2}$ is the half-life of radioactive nuclei. After passing every half-life the nuclei is reduced into further half of the initial and it become activity till it becomes negligible. The variation of half-life is from fraction of seconds to million of years.

Half –life of some of the metal given:

Metal		Half-life
P_0^{214}	P_0 -214 Plutonium	170μ sec
I^{137}	I -137 Irridium	25 sec
C^{14}	Carbon -14	2134 years
Th^{232}	Th -232	1.4×10^{10} years
U^{238}	Uranium -238	4.525×10^{9} years