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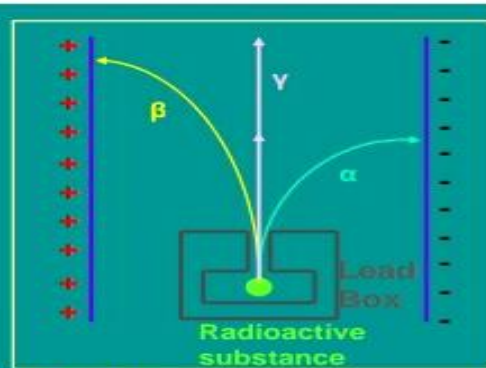
Class 12Sc Sub Physics Date 02 01 21

Radioactivity:

Radioactivity is the phenomenon of emitting alpha, beta and gamma radiations spontaneously.



Soddy's Displacement Law:

1. $_{Z}Y^{A} \xrightarrow{\alpha} {}_{Z-2}Y^{A-4}$
2. $_{Z}Y^{A} \xrightarrow{\beta} {}_{Z+1}Y^{A}$
3. $_{Z}Y^{A} \xrightarrow{\gamma} {}_{Z}Y^{A}$ (Lower energy)

Rutherford and Soddy's Laws of Radioactive Decay:

1. The disintegration of radioactive material is purely a random process and it is merely a matter of chance. Which nucleus will suffer disintegration, or decay first can not be told.
2. The rate of decay is completely independent of the physical composition and chemical condition of the material.
3. The rate of decay is directly proportional to the quantity of material actually present at that instant. As the decay goes on, the original material goes on decreasing and the rate of decay consequently goes on decreasing.

If N is the number of radioactive atoms present at any instant, then the rate of decay is,

$$-\frac{dN}{dt} \propto N \quad \text{or} \quad -\frac{dN}{dt} = \lambda N$$

where λ is the decay constant or the disintegration constant.

Rearranging,

$$\frac{dN}{N} = -\lambda\, dt$$

Integrating, $\log_e N = -\lambda t + C$ where C is the integration constant.

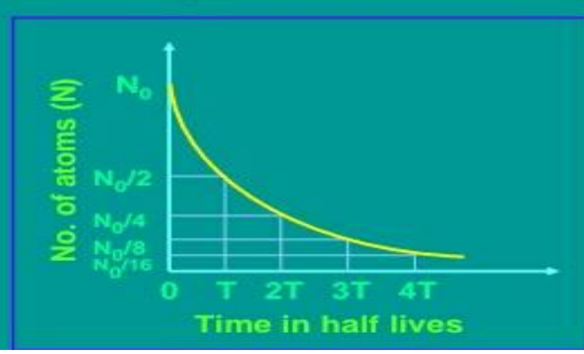
If at t = 0, we had N_0 atoms, then

$$\log_e N_0 = 0 + C$$

$\therefore \quad \log_e N - \log_e N_0 = -\lambda t$

or $\quad \log_e (N / N_0) = -\lambda t$

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



Radioactive Disintegration Constant (λ):

According to the laws of radioactive decay,

$$\frac{dN}{N} = -\lambda\, dt$$

If dt = 1 second, then

$$\frac{dN}{N} = -\lambda$$

Thus, λ may be defined as the relative number of atoms decaying per second.

Again, since $N = N_0 e^{-\lambda t}$

And if, $t = 1/\lambda$, then $N = N_0 / e$

or $$\frac{N}{N_0} = \frac{1}{e}$$

Thus, λ may also be defined as the reciprocal of the time when N / N_0 falls to 1 / e.

Half – Life Period:

Half life period is the time required for the disintegration of half of the amount of the radioactive substance originally present.

If T is the half – life period, then

$$\frac{N}{N_0} = \frac{1}{2} = e^{-\lambda T} \qquad (\text{since } N = N_0 / 2)$$

$$e^{\lambda T} = 2$$

$$\lambda T = \log_e 2 = 0.6931$$

$$T = \frac{0.6931}{\lambda} \quad \text{or} \quad \lambda = \frac{0.6931}{T}$$

Time t in which material changes from N_0 to N:

$$t = 3.323\, T \log_{10} (N_0 / N)$$

Number of Atoms left behind after n Half – Lives:

$$N = N_0 (1/2)^n \quad \text{or} \quad N = N_0 (1/2)^{t/T}$$