B.Sc. part II

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paper IV Group C

Page: 1

"Rutherford - Soddy's theory of radioactive - decay"

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Rutherford Soddy Law of Radioactive Decay In 1902, Rutherford and Soddy studied the disintegrating of many radioactive substance and found the following conclusion regarding radioactive decay known as Rutherford and Soddy Rules. According to:-

1. Radioactivity is a nuclear phenomenon and the rate of emission of radioactive ray cannot be controlled by physical or chemical process that mean neither can it be extended nor can it be reduced.

2. The nature of disintegration of radioactive substance is statistical, this is, it is very difficult to say which nucleus will be disintegrate which particle will

emit α, β and γ with the emission of the α, β and γ rays in process of disintegration one element change into another new element, its chemical and radioactive quantities are completely new.

3 At any time the rate of decay of radioactive atom is proportional to the number of atoms present at that time.
Let the number of atoms present at any given time t is N and at time $t+\Delta t$ this number decreases $N-\Delta N$ to its value then, the rate of decay of atoms is

$-\frac{\Delta N}{\Delta t}$. Therefore, according to law of Rutherford and Soddy.

If at the time Δt the nucleus ΔN will be disintegrated then the rate of disintegration $-\frac{dN}{dt} \propto N$.

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

or, $dN = -\lambda N dt$ ——— ①

Now, arranging equation ① again

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

Integrating both the sides, we have

$$\int_{N_0}^{N} \frac{dN}{N} = -\lambda \int_0^t dt$$

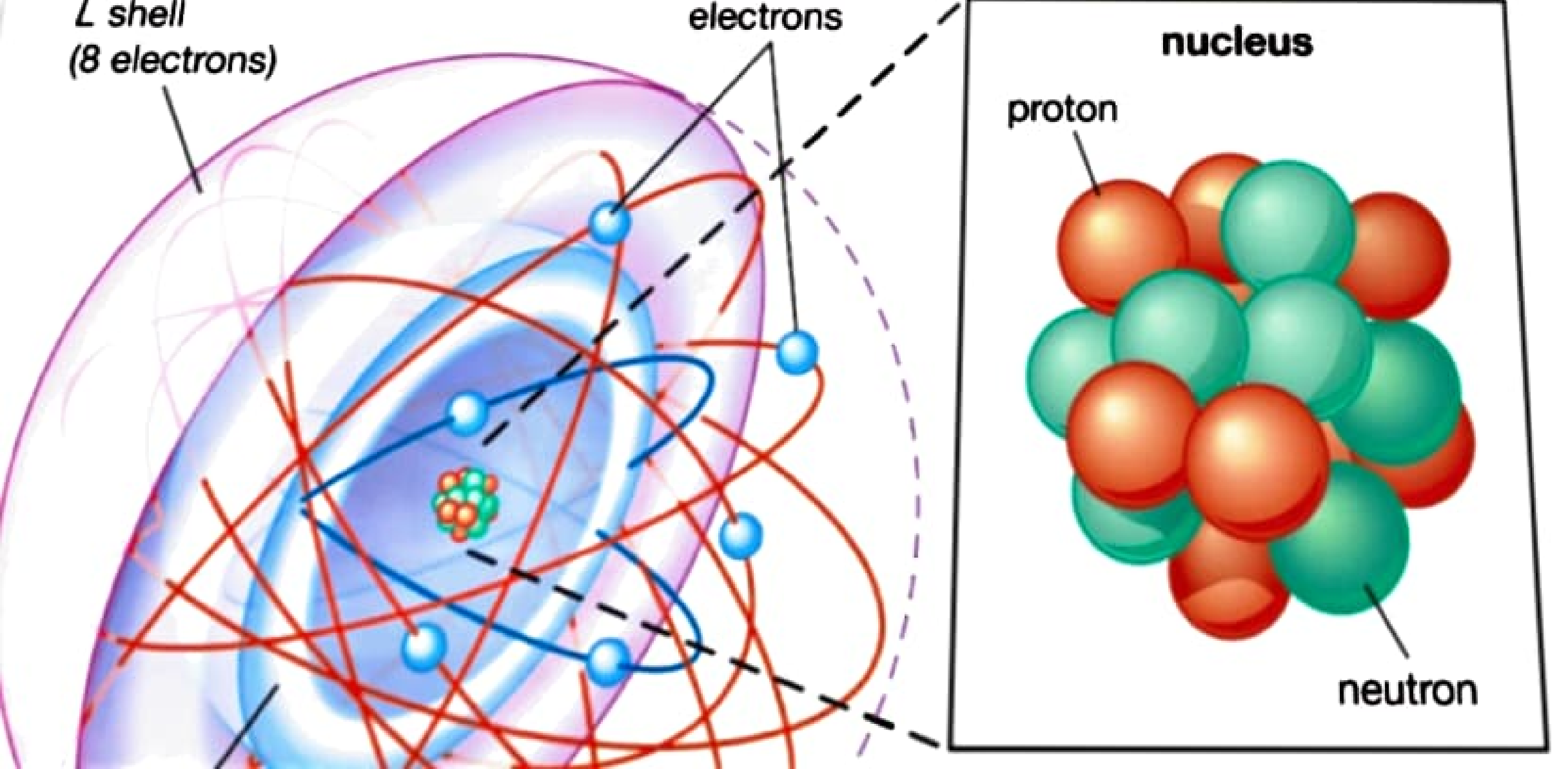
$\ln N - \ln N_0 = -\lambda t$ or

$$\ln \frac{N}{N_0} = -\lambda t$$

Taking the exponential on both the sides, we get

$$\frac{N}{N_0} = e^{-\lambda t} \quad \text{or} \quad N = N_0 e^{-\lambda t}$$ ——— ②

Where N_0 is the number of active nuclei at $t=0$.


L shell
(8 electrons)
electrons
nucleus
proton
neutron

From equation (2), it is apparent that the number of nuclei to be decayed decreases exponentially. It is shown in fig 1.
the number of nuclei decayed in time t,

$$N_0 - N = N_0 - N_0 e^{-\sigma t} = N_0(1 - e^{-\sigma t}) \quad \text{—— (3)}$$

Thus, fraction of decayed nuclei in time t,

$$\boxed{\frac{N_0 - N}{N_0} = 1 - e^{-\sigma t}}$$