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Radioactive Disintegration

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THE conventional development of parent-daughter relationships in radioactive disintegration follows the treatment given in Rutherford, Chadwick, and Ellis[1] in which a trial solution of the differential equations appropriate to the process is proposed, and the arbitrary constants are evaluated by application of boundary conditions. At the senior-graduate level at which the first course in nuclear physics is usually taught, the following derivation is believed to be considerably more instructive.

Writing unprimed symbols to represent parent nuclei, primed symbols to represent daughter nuclei, and calling N_0 the number of parent nuclei of disintegration constant λ present at time $\tau=0$, the number of daughter nuclei formed in a time interval $d\tau$ at time τ is $\lambda N_0 e^{-\lambda\tau} d\tau$. The number of daughter nuclei remaining at a later time t will be

$$dN' = (\lambda N_0 e^{-\lambda\tau} d\tau) e^{-\lambda'(t-\tau)},$$

and the total number of daughter nuclei on hand at time t may be found by summing the contributions from all $d\tau$ intervals from time 0 to time t:

$$N' = \int_0^t \lambda N_0 e^{-\lambda\tau} e^{-\lambda'(t-\tau)} d\tau = \left(\frac{\lambda}{\lambda'-\lambda}\right) N_0 (e^{-\lambda t} - e^{-\lambda' t}).$$

Reinterpretation of the symbols N, λ, t as intensity, absorption coefficient, and thickness results in the determination of the intensity of fluorescent radiation from an absorber where the unprimed symbols represent incident radiation and the primed symbols represent fluorescent radiation. The resulting equation has been reported by Insch[2] in connection with the calibration of proportional counters.

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[1] Rutherford, Chadwick, and Ellis, *Radiations from Radioactive Substances* (Cambridge University Press, London, 1930), p. 11.
[2] G. M. Insch, Phil. Mag. 41, 857 (1950).