

Decay models of unstable nuclei

Alpha α	Beta minus β^-	Beta plus β^+	Gamma γ
	N decay to P, emitting e and $\bar{\nu}_e$	(K capture)	nucleu in excited state emits photon-some after β decay
$^{241}_{95}\text{Am} \rightarrow ^{237}_{93}\text{Np} + ^4_2\alpha$	$^{63}_{28}\text{Ni} \rightarrow ^{63}_{29}\text{Cu} + e^- + \bar{\nu}_e$	$^{124}_{53}\text{I} + e^- \rightarrow ^{124}_{52}\text{Te} + \nu_e$	$^{99}_{42}\text{Mo} \rightarrow ^{99m}_{43}\text{Tc} + e^- + \bar{\nu}_e$
		m $\rightarrow$ metastable state	$^{99m}_{43}\text{Tc} \rightarrow ^{99}_{43}\text{Tc} + \gamma$
		nucleus in high excited state for extended time	time (grater than a billionth of a second)

Equations

decay rate	$\Delta N/\Delta t = -\lambda N$
activity	$A = \lambda N$
half life	$T = \ln 2/\lambda$
activity	$\ln 2N/T$
Number of atoms after decay	$N = N_0 e^{-\lambda t}$
activity after decay	$A = A_0 e^{-\lambda t}$
mass	mol x RAM

Definitions

spontaneous	can't be influenced/independent
random	can't predict when it will happen
decay constant	probability of a nucleus decaying per unit time
activity	number of disintegrations (or emissions) per unit time
metastable state	when an atom/nucleus exists for an extended time in a state other than ground state
daughter nucleus	product of the decay of a radioactive ('parent') nucleus
half life	time taken for half of a sample of radioactive nuclei to decay

radioactive decay

--> the significance of the - sign in $-\lambda N$ is that the number of radioactive nuclei in a sample material decreases over time

Example Question:

. Lanthanum-139 is the more abundant isotope and makes up 99.911% of naturally occurring lanthanum. The remaining 0.089% is the radioisotope lanthanum-138 . Lanthanum-138 has a decay constant of $2.0 \times 10^{-19} \text{ s}^{-1}$; and 139g of lanthanum contain 6×10^{23} atoms.

Calculate the activity of a 40g sample of Lanthanum

The number of atoms in 40g of lanthanum is $6 \times 10^{23} \times 40/139 = 1.73 \times 10^{23}$

However, only 0.089% of these are lanthanum-138.

So the number of lanthanum-138 nuclei is $N = 1.73 \times 10^{23} \times 0.089/100 = 1.54 \times 10^{20}$

so

$A = \lambda N$

$= 2.0 \times 10^{-19} \text{ s}^{-1} \times 1.54 \times 10^{20}$

$= 31 \text{ Bq}$

Uses of radioisotopes:

Radiotherapy

- Gamma rays γ
- rotating source of gamma rays
 - reduces exposure to healthy tissue
 - focuses exposure to tumor
- Alpha rays α
- injected directly into the tissue
 - attach to a biological molecule (eg glucose) that needs to divide
 - collects to the caner cells that love to divide

Carbon dating

- uses ^{14}C (half life of 5700 years)
- The ratio of Carbon-14 remaining indicates the times since the death of a living substance

Nuclear Instability

- every element has many different isotopes
- however most isotopes are unstable, and decay by emission of radiation to become more stable
- this can be plotted on a no. Neutrons to no. Protons graph



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