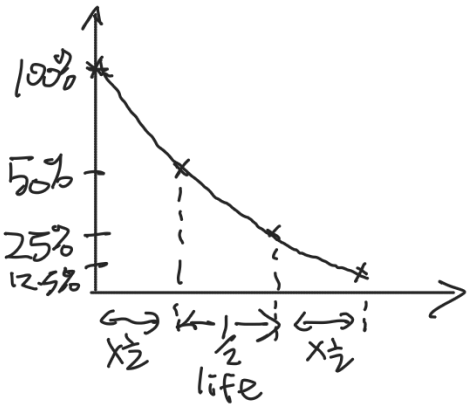
Rate of Decay and Uses of Radionuclides

Radio active decay is a random process

Half Life

Time when undecay % is half
HALF LIFE



$$N = N_0 \left[\frac{1}{2}\right]^n$$

- N: undecay nuclei after $n \times \frac{1}{2}$ lifes
- N_0: original undecay nuclei
- n: no of ½ life

e.g. iodine-131 (8 days) ; carbon-14 (5700 yrs) ; uranium-238 (4.47×10^9 yrs)

Activity (A) is a measure of the strength of radio active sample

unit: no of disintegration per second (s^{-1}) becquerel (Bq)

$A \propto N$; therefore: $A = A_0 \left(\frac{1}{2}\right)^n$ ← no of ½ lifes

- A: activity of sample after $n \times \frac{1}{2}$ lifes
- A_0: initial activity of sample

Since $A \propto N \Rightarrow A = kN$

and $k = \frac{A}{N} = \frac{\text{no of decayed nuclei decayed per s}}{\text{total number of undecayed nuclei}}$

= probability of decay per unit time.

decay constant. (unit: s^{-1})

Decay Law

$N = N_0 e^{-kt}$ ($e = 2.718$ Euler's number)

find A, N at time (t)

$A = A_0 e^{-kt}$

$T_{\frac{1}{2}} = \frac{\ln 2}{k}$ ← natural log of 2 ← decay constant

half life time

Uses of Radio Nuclides

γ : higher penetration
β : lower penetration

Medical (Cancer Treatment):
- External Radio Therapy (γ rays) long ½ life
- Internal Radio Therapy (β rays) short ½ life
- Medical Traces (γ rays) short ½ life

Industrial:
- Detect underground pipe leaks (γ, short ½ life)
- Metal sheet thickness (β, long ½ life)

Domestic:
- Smoke detector (α, long ½ life)
  - no smoke, α source creats ions, current flows.
  - smoke, α source is neutralized by smoke, currant cannot flow.

Archaeological (考古)

carbon dating C-14 half life ≈ 5730 yrs

when animals and plants die → ${}^{14}_{6}C \rightarrow {}^{14}_{7}N + {}^{0}_{-1}e$

(β radioactive)

just dead : activity = A_0

after 5730 yrs : activity = $0.5 A_0$ × ½ life

after 11460 yrs : activity = $0.25 A_0$ × ½ × ½ life

Radiation Safety

* Ionizing radiation is harmful
* How harmful?
  1. Absorbed dose
  2. Type of radiation
  3. Which tissue or organ.

Effective dose (unit: sievert Sv)
measures the overall biological effects

10 mSv : No effect
100 mSv : Increase in cancer
1 Sv : vomit, nausea
10 Sv : radiation sickness
die within weeks
100 Sv : instant death