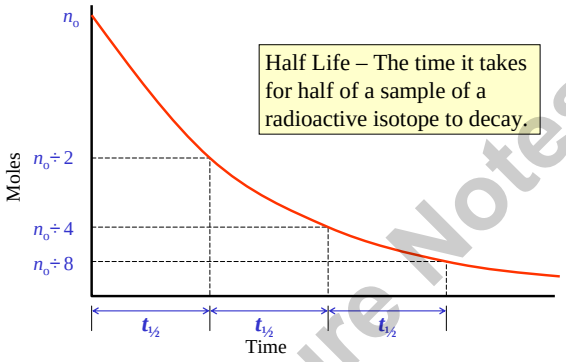
Nuclear Half-Life

The half life of a radioactive isotope

- The time it takes for half of a radioactive sample of an isotope to decay.
- Temperature changes do not affect the rate of nuclear decay.

- After two half lives have passed…
  - **1/8 of the original sample will remain.**

Half Life for Nuclear Decay



Ex1) Nuclear Decay Half Life

Ex1) Sodium-24 has a half life of 15 hours. If A 30.0 g sample of pure ^{24}Na is isolated, what mass of the isotope will remain after 120 hours.

Step 1. Determine the number of half lives

Ex1) Nuclear Decay Half Life (cont.)

Ex1) Sodium-24 has a half life of 15 hours. If A 30.0 g sample of pure ^{24}Na is isolated, what mass of the isotope will remain after 120 hours.

Step 2. Determine the mass that remains

Ex2) Nuclear Decay Half Life

Ex2) A 2.20×10^2 g sample of a certain radioactive isotope decays to 27.5 g in 12 days. What is the half life of this isotope.

Step 1. Determine the number of half lives

Ex2) Nuclear Decay Half Life (cont.)

Ex2) A 2.20×10^2 g sample of a certain radioactive isotope decays to 27.5 g in 12 days. What is the half life of this isotope.

Step 2. Determine the half life of the isotope

Half Life Formula

$$t_{½} = \frac{0.693}{k}$$

k = decay constant (time^{-1})
$t_{½}$ = half life (time)

Ex3) Nuclear Decay Half Life

Ex3) The half life of radon-222 is 3.82 days. Find the decay constant for radon-222.

$$t_{½} = \frac{0.693}{k}$$

1st Order Integrated Rate Law

$$-kt = \ln\left(\frac{N_t}{N_o}\right)$$

k = decay constant (time^{-1})
t = period of event (time)
N_o = initial amount of the isotope (molarity, moles, atoms, grams, disintegration rate)
N_t = amount of isotope remaining at the end of the event (molarity, moles, atoms, grams, disintegration rate)

Carbon-14 Dating

- Carbon-12 is a stable isotope.
- Carbon-14 decays through beta decay.

$$^{14}_{6}C \rightarrow {}^{0}_{-1}e + {}^{14}_{7}N$$

- Carbon-14 is produced when high energy neutrons from space collide with nitrogen-14 in the atmosphere.

$$^{14}_{7}N + {}^{1}_{0}n \rightarrow {}^{14}_{6}C + {}^{1}_{1}H$$

- The rate of these process are equal, so the amount of carbon-14 in the atmosphere remains constant.

Carbon-14 Dating

- All living organisms absorb carbon and incorporate it into their molecules.
  - Plants absorb $CO_{2(g)}$.
  - Animals eat plants and/or animals that eat plants.
- Until the day that an organism dies, its $^{14}_{6}C/^{12}_{6}C$ ratio remains the same as that in the atmosphere.
- After death, its $^{14}_{6}C/^{12}_{6}C$ ratio decreases in accordance with the half life of carbon-14, as carbon-12 is stable.
- The half life of carbon-14 is 5730 years.

Ex4) Nuclear Decay Half Life

Ex4) The body of an ancient human, named Grauballe Man, was found in a bog in Jutland, Denmark. A lab technician found that the carbon-14 from this body had a decay rate of 2330 disintegrations per second. The average living human experiences approximately 3080 disintegrations per second.

How many years has it been since the man died.

Ex4) Nuclear Decay Half Life (cont.)

Step 1. Find the decay constant for C-14

Ex4) Nuclear Decay Half Life (cont.)

Step 2. Find the number of years since he died