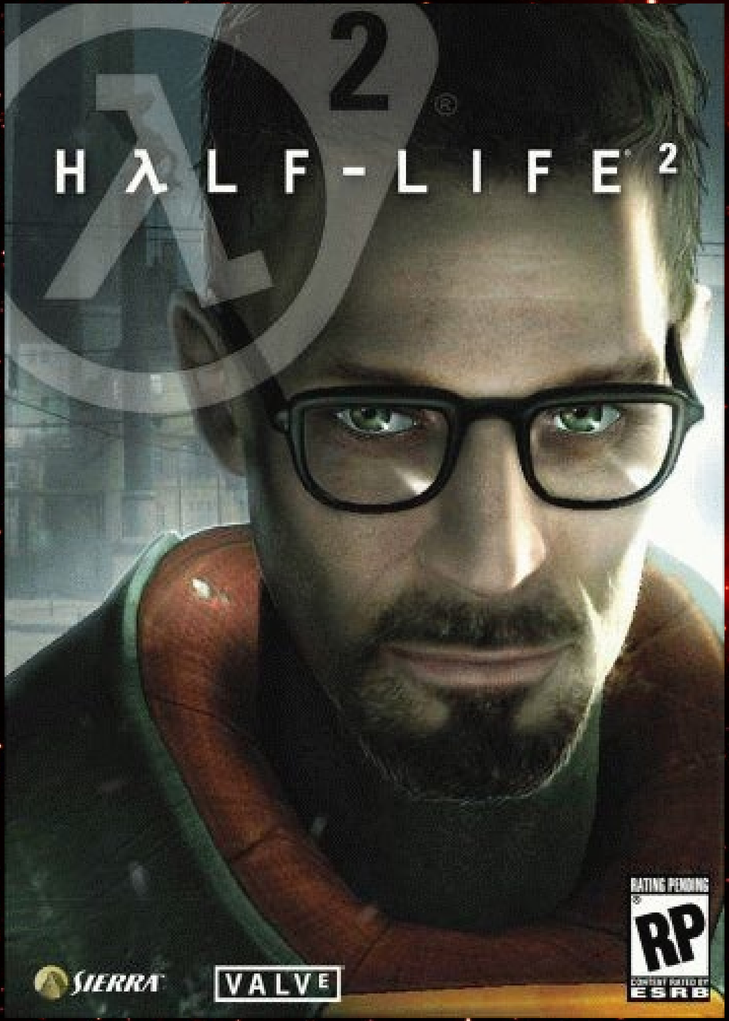
Radioactive Half-Lives



Lesson 8

Objectives

- perform simple, non-logarithmic half life calculations.
- graph data from radioactive decay and estimate half life values.
- graph data from radioactive decay and infer an exponential relationship between measured radioactivity and elapsed time.

Review Questions

Diploma Question Alert!

31. Nuclear radiation exists in several different forms. Listed from greatest to least in their ability to penetrate human tissue, the order of three of these forms is

- **A.** alpha, beta, gamma
- **B.** gamma, beta, alpha
- **C.** gamma, alpha, beta
- **D.** alpha, gamma, beta

Ans: B

Use the following information to answer the next question.

> When a neutron is captured by a nucleus of uranium-238, the event shown below occurs.
>
> $${}^{238}_{92}\mathrm{U} + {}^{1}_{0}\mathrm{n} \rightarrow {}^{239}_{92}\mathrm{U}$$
>
> The uranium-239 then undergoes a series of decays:
>
> $${}^{239}_{92}\mathrm{U} \xrightarrow{\text{decay I}} {}^{239}_{93}\mathrm{Np} \xrightarrow{\text{decay II}} {}^{239}_{94}\mathrm{Pu}$$

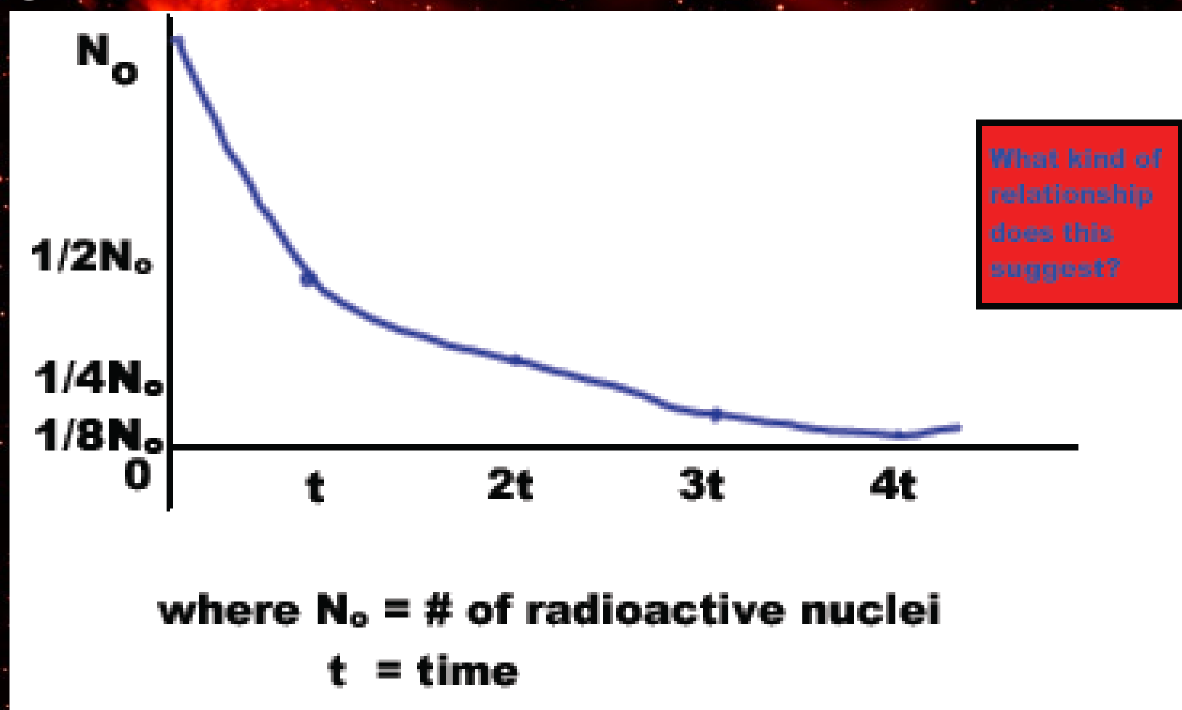
32. In both decays I and II, the type of emitted particle is

- **A.** an alpha particle
- **B.** an electron
- **C.** a neutron
- **D.** a proton

Ans: B

Half-Lives

- In P30, we are concerned with the rate at which decay occurs
- If we construct a graph of the number of atoms vs. time of a particular radioactive isotope, we would find the following:



Explanation

- The graph is exponential, so there must be an exponential relationship between the number of nuclei decaying and time.
- In one period of time, one half of the initial nuclei, N_o, decay.
- In another period of time, one half of one half ($1/4N_o$) decay.

Formula

- Once a radioactive element has undergone decay it is changed into something else (trasmuted).
- This means that the number of parent nuclei is continuously decreasing.
- A quantitative measure of longevity of a particular isotope is its half-life.
- This is the time it takes one half of a radioactive sample to decay.

Formula

- A mathematical equation that can model this decay is:

$$N = N_o(1/2)^n$$

where:

N = number of nuclei remaining

N_o = initial amount of nuclei

n = number of periods of time passing: the number of half-lives

Three Units of N

- Sometimes questions are phrased with

  N = number of nuclei,

  but this is not practical in real life. More often,

  N = a mass of a radioactive material (kg).

  Other times, N is expressed as an activity, the number of decays per second:

  N = activity of radioactive material (Bq).

Half-Life Examples

- Some elements have very short half-lives: polonium-214 has a half-life of 1.64×10^{-4} s,

krypton-89 is 3.16 min

uranium-238 is 4.47×10^{9} years

indium-115 is 4.41×10^{14} years.

Number of Decays

- We can calculate the number of half lives of a substance by taking the time it is decaying for and dividing by the time of one half life.

$$n = \frac{time}{t_{1/2}}$$

time: total time of decay

$t_{1/2}$: half-life

Example

- Radon-222 has a half-life of 3.83 days. How many half-lives have passed after one year?

  Answer: 95

- If we start off with 10 mg of this sample, how much remains after a year?

  Answer: $2.05x10^{-34}$ kg

More Examples

- The $t_{1/2}$ of strontium is 28.5 years. What percentage of the original sample remains after 100 years?

  Answer: 8.79%

- A sample of putnamium-11 has a half life of 20 weeks. After 52 weeks, its activity is 18.0 Bq. What was the sample's original activity?

  Answer: 109 Bq