Wednesday, May 15/13
Science 122

Announcements

**** Need an activity re a course topic before the end of <u>May</u>.**

1. Assessment - Thermodynamics
2. Radioactive Decay
3. Decay Series
4. Half-Life
5. Activity and Decay Constants
6. Worksheet - Half-Life, Activity and Decay Constant #1 - HW

Example #1
(Giancoli #37, Page 941)

The decay constant of a given nucleus is 5.4 x 10^{-3} s^{-1}.
What is its half-life in minutes? (2.1 minutes)

$\lambda = 5.4 \times 10^{-3} s^{-1}$

$T_{1/2} = ?$

$T_{1/2} = \frac{0.693}{\lambda}$

$T_{1/2} = \frac{0.693}{5.4 \times 10^{-3} s^{-1}}$

$T_{1/2} = 128.3 s$

$T_{1/2} = 2.1 min$

Example #2
(Giancoli #47)

$^{233}_{92}U$ (92)

A sample of uranium-233 ($T_{1/2} = 1.59 \times 10^5$ yr) contains 6.50×10^{19} nuclei.

a) What is the decay constant of uranium-233? ($1.38 \times 10^{-13}\ s^{-1}$)
b) What is the activity when 6.50×10^{19} nuclei are present? (8.97×10^6 Bq)

a) $\lambda = ?$ $\quad \lambda = \frac{0.693}{T_{1/2}}$

$1.59 \times 10^5\ yr \times \frac{3.156 \times 10^7\ s}{1\ y} = 5.018 \times 10^{12}\ s$

$\lambda = \frac{0.693}{5.018 \times 10^{12}\ s}$

$\lambda = 1.38 \times 10^{-13}\ s^{-1}$

b) $A = \lambda N$

$A = (1.38 \times 10^{-13}\ s^{-1})(6.50 \times 10^{19})$

$A = 8.97 \times 10^6\ Bq$

Example #3

Suppose there are 3.0×10^7 radon atoms trapped in a basement.
The half-life of radon is $T_{1/2} = 3.83$ days or 3.31×10^5 s.

a) How many radon atoms remain after 31 days? (1.1×10^5)
b) Find the activity
   (i) just after the basement is sealed. (63 Bq)
   (ii) 31 days later. (0.23 Bq)

$N_0 = 3.0 \times 10^7$

$T_{1/2} = 3.83$ days $= 3.31 \times 10^5$ s

a) $N = N_0 e^{-\lambda t}$ ← 31 days

$\lambda = \frac{0.693}{T_{1/2}}$

$\lambda = \frac{0.693}{3.83 \text{ days}}$

$\lambda = 0.1809 \text{ days}^{-1}$

$N = (3.0 \times 10^7) e^{-(0.1809)(31)}$

$N = 1.1 \times 10^5$

b) (i) $A_0 = \lambda N_0$

$\lambda = 2.094 \times 10^{-6} \text{ s}^{-1}$

$A_0 = (2.094 \times 10^{-6})(3.0 \times 10^7)$

$A_0 = 63 \text{ Bq}$

(ii) $A = \lambda N$

$A = (2.094 \times 10^{-6})(1.1 \times 10^5)$

$A = 0.23 \text{ Bq}$

Example #4

(#33, Page 963)

A device used in radiation therapy for cancer contains 0.50 g of cobalt-60 (59.934 g/mol). The half-life of cobalt-60 is 5.27 yr. Determine the activity of the radioactive material. (2.1×10^{13} Bq)

$m = 0.50\,g$

$M = 59.934\,g/mol$

$T_{1/2} = 5.27\,yr$

$A = \lambda N$

$yr \rightarrow s.$

$\lambda = \frac{0.693}{T_{1/2}}$

$\lambda = 4.167 \times 10^{-9}\,s^{-1}$

$n = \frac{m}{M}$

$n = \frac{N}{N_a}$

$N = 5.022 \times 10^{21}$

$A = \lambda N$

$A = 2.1 \times 10^{13}\,Bq$

Handout: Half-Life, Activity and Decay Constant

Science 122

Half-Life, Activity and Decay Constant

1. In 9.0 days, the number of radioactive nuclei decreases to one-eighth the number present initially. What is the half-life (in days) of the material? (3.0 days)

2. The isotope radium-224 has a decay constant of $2.19 \times 10^{-6}\ s^{-1}$. What is the half-life (in days) of this isotope? (3.66 days)

3. How many half-lives are required for the number of radioactive nuclei to decrease to one-millionth of the initial number? (19.9)

4. Iodine-131 is used in diagnostic and therapeutic techniques in the treatment of thyroid disorders. This isotope has a half-life of 8.04 days. What percentage of an initial sample of iodine-131 remains after 30.0 days? (7.53%)

5. Strontiun-90 has a half-life of 28.5yr. It is chemically similar to calcium, enters the body through the food chain and collects in the bones. Consequently, strontium-90 is a particularly serious health hazard. How long (in years) will it take for 99.9900% of the strontium-90 released in a nuclear reactor accident to disappear? (379 years)

6. If the activity of a radioactive substance is initially 398 disintegrations/min and two days later it is 285 disintegrations/min, what is the activity four days after the first two days? Give your answer in terms of disintegrations per minute. (146 disintegrations/min)

7. To make the dial of a watch glow in the dark, 1.000×10^{-9} kg of radium-226 is used. The half-life of this isotope is 1.60×10^{3} years. How many kilograms of radium disappear while the watch is in use for fifty years? (2.1×10^{-11} kg)

8. A sample of ore containing radioactive strontium-90 has an activity of 6.0×10^{5} Bq. The molar mass of strontium-90 is 89.908 g/mol and its half-life is 28.5 years. How many grams of strontium are in the sample? (1.2×10^{-7} g)