

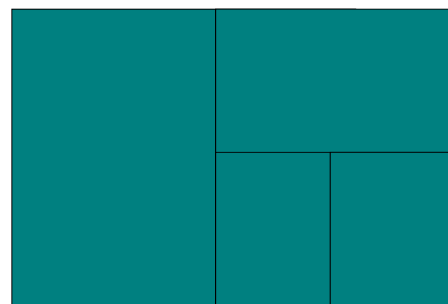
PHYSICS 3204
WORKSHEET #8: HALF LIFE



Different radioactive isotopes have different rates of decay. The time required for one-half of a radioactive sample to decay is called the **half-life** or $T_{1/2}$.

The half-life ($T_{1/2}$) of carbon-14 is 5730 years

Amount of carbon-14	Time since original sample
32 g	0 a (years)
16 g	5730 a {1 half-life}
8 g	11460 a {2 half-life intervals}
4 g	17190 a {3 half-life intervals}



Half-life formula:

$$N = N_0 \left(\frac{1}{2} \right)^{\left(\frac{t}{T_{1/2}} \right)}$$

where:

N = number of nuclei remaining after time **t**

N₀ = number of nuclei initially

t = time which has past

T_{1/2} = half-life of the particular isotope

Instead of measuring number or mass of nuclei present, radioactivity can be measured by number of nuclei decaying per second, known as the activity. The unit becquerels (Bq) is for decays per second.

$$A = A_0 \left(\frac{1}{2} \right)^{\left(\frac{t}{T_{1/2}} \right)}$$

where

A = number of nuclei decaying per second after time **t**

A₀ = initial activity

t = time which has past

T_{1/2} = half-life of the particular isotope

Example:

Plutonium-239 (${}_{94}^{239}\text{Pu}$) has a half-life of 2.44×10^4 a as it α decays. If you have a sample with 2.5 g of plutonium-239, how long will it take for it to decay to only 1.0 g?

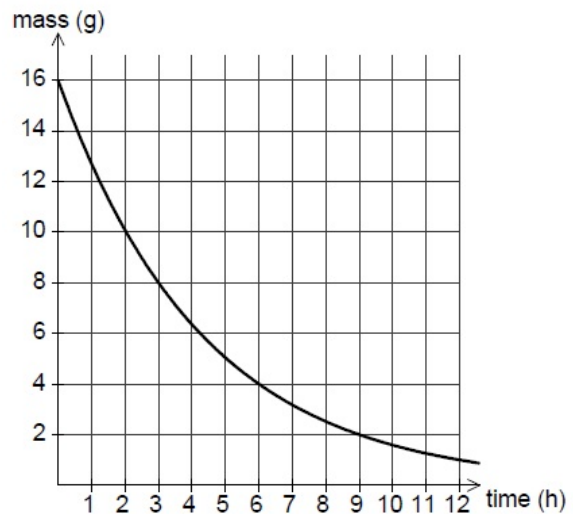
PART A: MULTIPLE CHOICE

1. A radioactive material has an initial activity of 1320 Bq. What is its activity after 9.0 h if its half-life is 3.2 h?

- (A) 1.9×10^2 Bq
- (B) 2.4×10^2 Bq
- (C) 1.0×10^3 Bq
- (D) 1.2×10^3 Bq

2. What is the half-life of the unknown substance shown?

- (A) 2 h
- (B) 3 h
- (C) 8 h
- (D) 10 h



3. A sample of radioactive material has an initial activity of 1.50×10^6 Bq. After how many half-lives will the activity decrease to 3.75×10^5 Bq?

- (A) $\frac{1}{4}$
- (B) $\frac{1}{2}$
- (C) 2
- (D) 4

4. The half-life of a radioactive material is 14.7 years. How long will it take for a sample of this material to decay to 2.50% of its initial amount?

- (A) 29.4 years
- (B) 58.8 years
- (C) 78.2 years
- (D) 147 years

5. After 15 days, a sample of a radioactive gas decays to 65% of its original mass. What is the half-life of this radioactive gas?

- (A) 7.5 days
- (B) 9.3 days
- (C) 22 days
- (D) 24 days

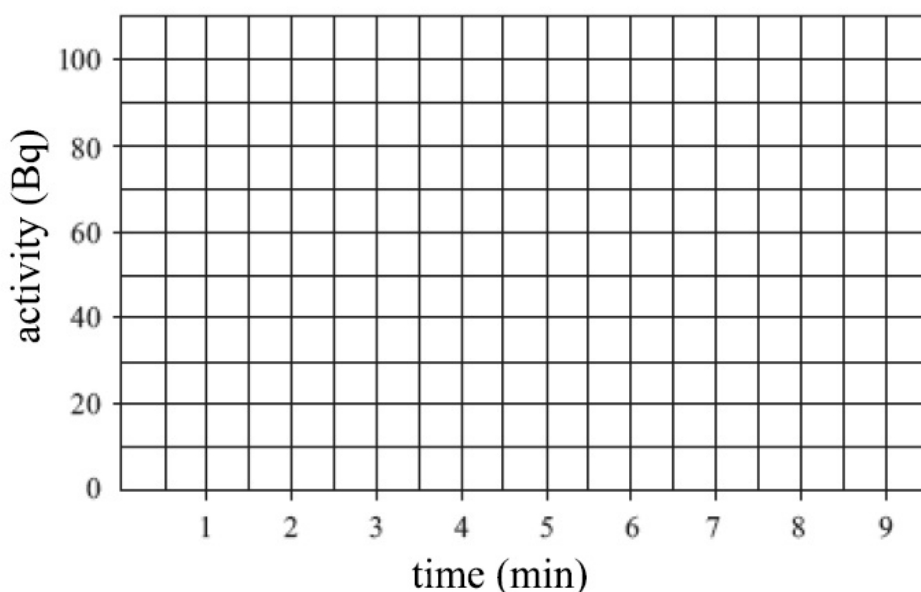
6. How much of a 60.0 g radioactive isotope remains after four half-lives?

- (A) 3.75 g
- (B) 7.50 g
- (C) 9.60 g
- (D) 15.0 g

7. An isotope of krypton has a half-life of 3 minutes. If a sample of this isotope produces 1000 counts per minute in a Geiger counter, how many counts per minute are produced after 15 minutes?
- (A) 0
(B) 15
(C) 30
(D) 60
8. A Geiger counter detects 240 decays per minute from a pure radioactive sample. If the rate reduces to 15 decays per minute after 12 days, what is the half life of the sample?
- (A) 3 days
(B) 4 days
(C) 8 days
(D) 15 days
9. If element A has a half-life of 5 days, how many days will it take a 1.0×10^2 mg sample to decay to 12.5 mg?
- (A) 3
(B) 8
(C) 15
(D) 20

PART B: WRITTEN RESPONSE

1. Cesium-137 has a half-life of 30.2 years and is found in the radioactive waste products of nuclear power production. Calculate the time required for the activity of a sample of cesium-137 to reduce to 18% of its original value. JUNE 2009
2. A radioactive sample has a half-life of 2.5 minutes, and the initial activity of the sample is 100 Bq. AUGUST 2007
- (i) On the grid below, sketch a graph of activity versus time for this sample for the first 7.5 minutes.



- ii) Using the graph, determine the activity of this sample at 6.0 minutes.

3. Calculate the half-life of a radioactive substance that decays from an initial amount of 2.00×10^{-3} g to 1.35×10^{-4} g in 3.0 h. JUNE 2007
4. Strontium - 82 has a half-life of 25.0 days. If a sample originally contained 140 g of strontium - 82, in how many days will the sample contain 7.5 g of the isotope? AUGUST 2006
5. Iodine - 131 has a half-life of 8.04 days. If a sample originally has an activity of 2.00×10^6 Bq, how long will it take for it to have an activity of 1.85×10^6 Bq? JUNE 2006
6. If element X has a half-life of 6 days, how many days will it take a 1.3×10^2 mg sample to decay to 15 mg? AUGUST 2004