

EARTH HISTORY

AIM 3: What is radioactive dating?

HW

- Read “What Is Radioactive Dating?” p132-134
- Do all questions on Part A on p134

Review Unit

- Do all Chapter Review Questions p134-140

The relative time scale is an inferred order of events.

Ex: the top layer of rock strata is the youngest.

The absolute time scale gives the absolute age of an object (measured in years) using radioactive isotopes.

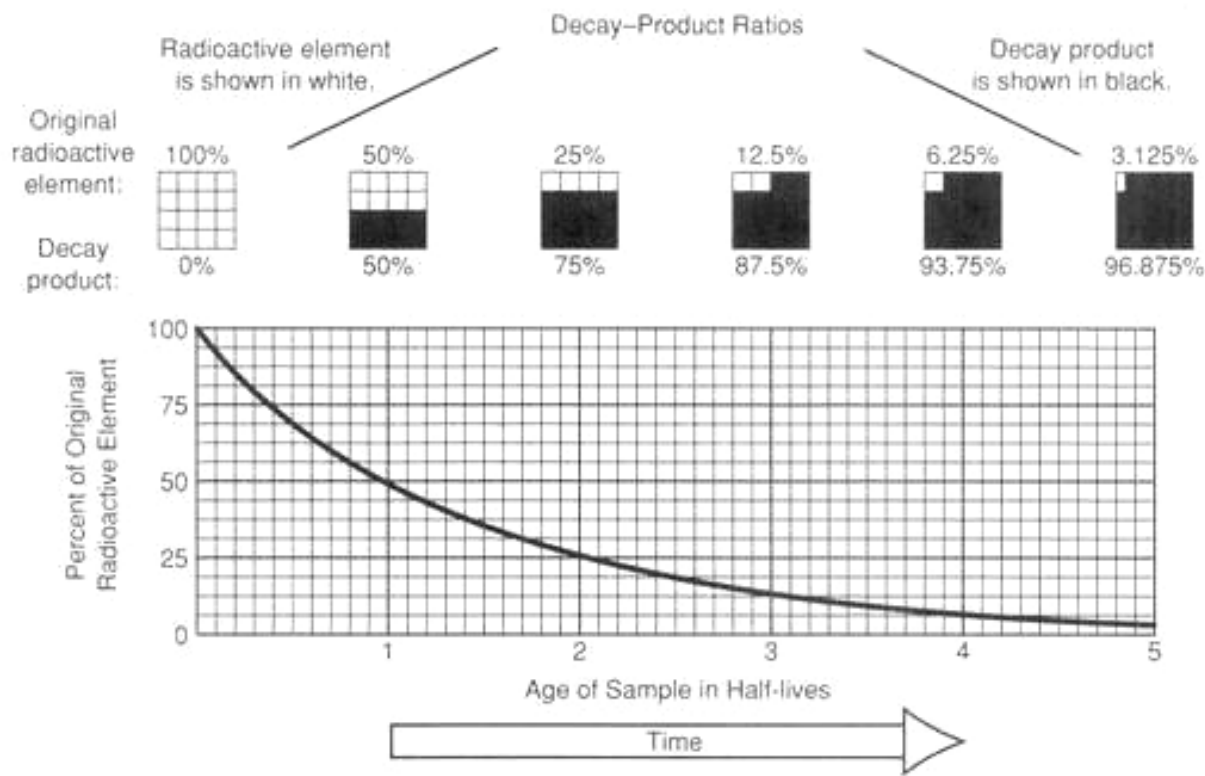
- A radioactive isotope is an atom that disintegrate or decay into another element.
Ex: C-14 decays into N-14 (the decay product)
- A half-life is the time required for half of a radioactive isotope's atoms in a sample to change to its decay product.
Ex: Starting with a 100 g sample of C-14, after 1 half-life or 5,700 years 50 g of C-14 remains and 50 g of N-14 is formed.

Radioactive Decay Data

RADIOACTIVE ISOTOPE	DISINTEGRATION	HALF-LIFE (years)
Carbon-14	$C^{14} \rightarrow N^{14}$	5.7×10^3
Potassium-40	$K^{40} \begin{cases} \rightarrow Ar^{40} \\ \rightarrow Ca^{40} \end{cases}$	1.3×10^9
Uranium-238	$U^{238} \rightarrow Pb^{206}$	4.5×10^9
Rubidium-87	$Rb^{87} \rightarrow Sr^{87}$	4.9×10^{10}

The ratio between the remaining mass of a radioactive isotope and its decay product(s) in a sample is the decay-product ratio. Using this ratio we can calculate how many half-lives have elapsed since the sample was formed.

Number of half-life elapsed	0	1	2	3	4	5
Fraction of radioisotope remaining	1	1/2	1/4	1/8	1/16	1/32
Fraction of decay product formed	0	1/2	3/4	7/8	15/16	31/32



Ex: If in a rock sample equal amount of U-238 and Pb-206 are present 1 half-life has elapsed therefore the rock is 4.5×10^9 years old.

Ex: If in a fossil bones 1/8 of the original C-14 remains, 3 half-life have elapsed, therefore the bone is 3 times 5.7×10^3 years or 1.7×10^4 years.

Radioactive isotopes with relatively short half-life such as C-14 are used to measure the absolute age of relatively recent organic fossils.

Radioactive isotopes with relatively long half-life such as U-238 are used to measure the absolute age of the oldest rocks on our planet.

Test your understanding

1/08

29 A whalebone that originally contained 200 grams of radioactive carbon-14 now contains 25 grams of carbon-14. How many carbon-14 half-lives have passed since this whale was alive?

- (1) 1 (2) 2 (3) 3 (4) 4

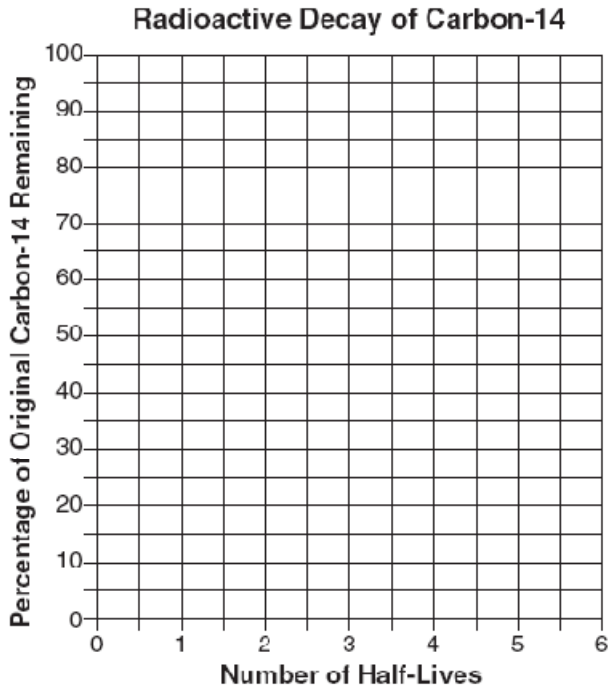
6/08

Base your answers to questions 66 through 68 on the data table below, which shows the radioactive decay of carbon-14. The number of years required to complete four half-lives has been left blank.

Radioactive Decay of Carbon-14

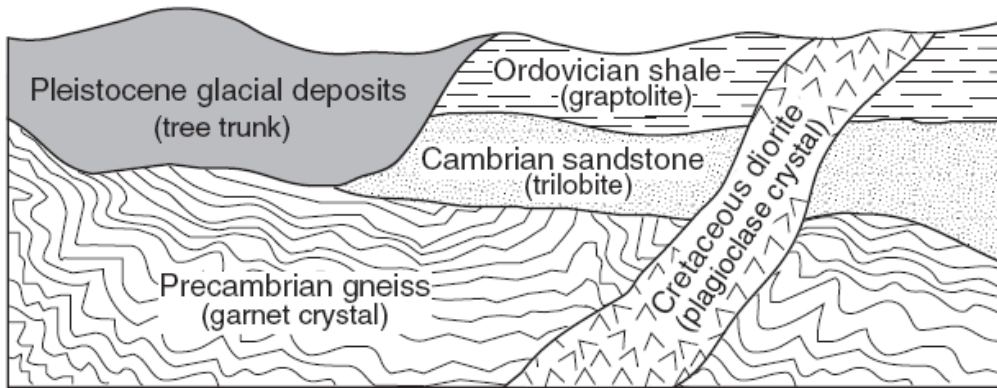
Number of Half-Lives	Percentage of Original Carbon-14 Remaining	Time (years)
0	100	0
1	50	5700
2	25	11,400
3	12.5	17,100
4	6.3	
5	3.1	28,500
6	1.6	34,200

66 On the grid below, construct a graph that shows the radioactive decay of carbon-14 by plotting an **X** to show the percentage of original carbon-14 remaining after *each* half-life. Connect the **X**s with a smooth, curved line.



67 How long does it take for radioactive carbon-14 to complete four half-lives?

68 The cross section below shows part of Earth's crust. The objects in parentheses indicate materials found within each rock unit or deposit.

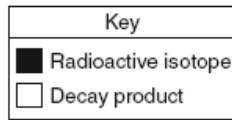


Which object in parentheses could be accurately dated using carbon-14? Explain your answer.

8/08

23 The diagram below represents a sample of a radioactive isotope.

Sample before decay



Which diagram best represents the percentage of this radioactive isotope sample that will remain after 2 half-lives?



(1)



(2)



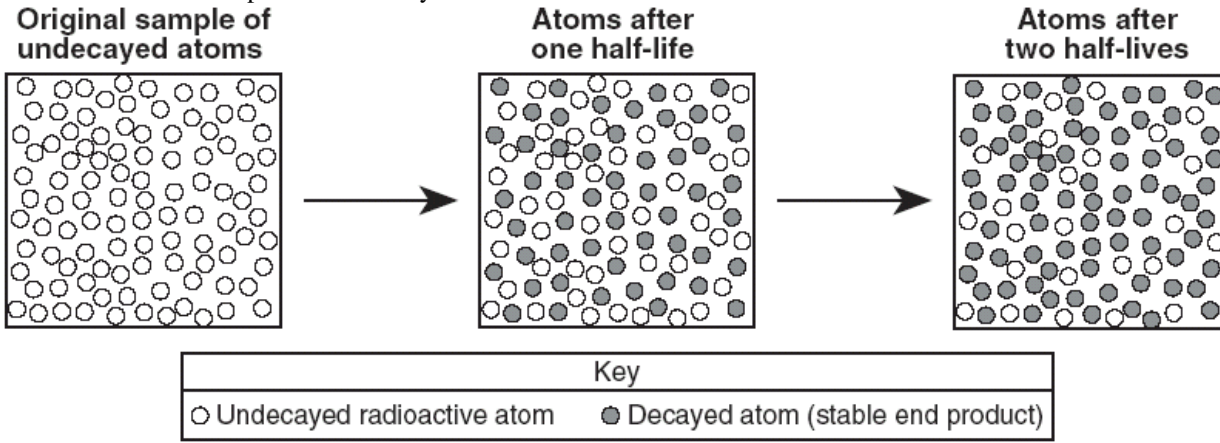
(3)



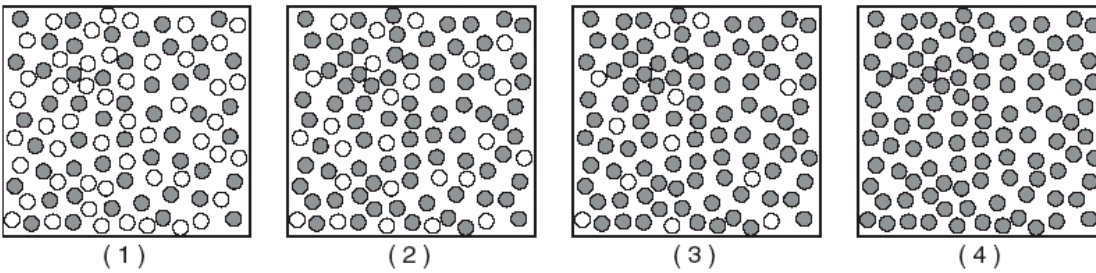
(4)

1/07

15 The models below represent the decay of radioactive atoms to stable atoms after their first and second half-lives.

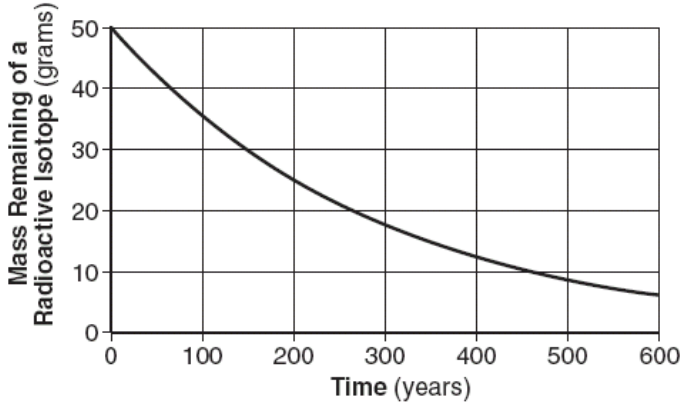


Which model best represents the number of undecayed and decayed atoms after three half-lives?



8/07

34 The graph below shows the radioactive decay of a 50-gram sample of a radioactive isotope.



According to the graph, what is the half-life of this isotope?

- (1) 100 years (2) 150 years (3) 200 years (4) 300 years

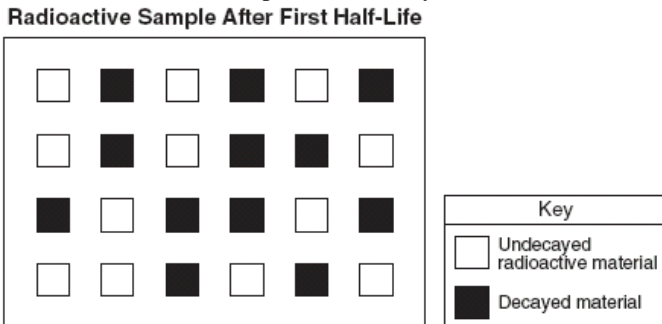
1/06

14 A fossil shell contains 25% of the original amount of its carbon-14. Approximately how many years ago was this shell part of a living organism?

- (1) 5,700 years ago (2) 11,400 years ago (3) 17,100 years ago (4) 22,800 years ago

6/06

Base your answers to questions 42 and 43 on the diagram below, which represents a model of a radioactive sample with a half-life of 5000 years. The white boxes represent undecayed radioactive material and the shaded boxes represent the decayed material after the first half-life.



42 How many *more* boxes should be shaded to represent the additional decayed material formed during the second half-life?

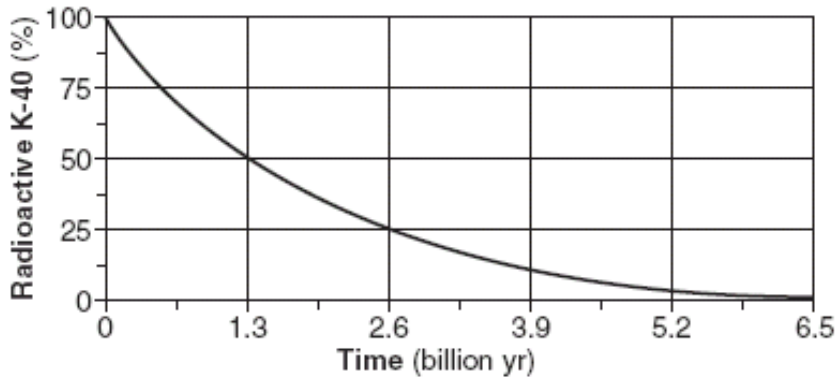
- (1) 12 (2) 6 (3) 3 (4) 0

43 Which radioactive isotope has a half-life closest in duration to this radioactive sample?

- (1) carbon-14 (2) potassium-40 (3) uranium-238 (4) rubidium-87

8/06

35 The graph below shows the rate of decay of the radioactive isotope K-40 into the decay products Ar-40 and Ca-40.



Analysis of a basalt rock sample shows that 25% of its radioactive K-40 remained undecayed. How old is the basalt?

- (1) 1.3 billion years (2) 2.6 billion years (3) 3.9 billion years (4) 4.6 billion years

1/04

16 Fossil pollen has been recovered from sediments deposited in late-Pleistocene lakes. The pollen's geologic age can most accurately be measured by using

- (1) rubidium-87 (3) oxygen-18 (2) potassium-40 (4) carbon-14

28 Uranium-238 that crystallized at the same time Earth formed has undergone approximately how many half-lives of radioactive decay?

- (1) one half-life (3) three half-lives (2) two half-lives (4) four half-lives

6/04

61 The vesicular basalt includes zircon crystals containing the radioactive isotope U-235, which disintegrates to the stable isotope Pb-207. The zircon crystals have 98.44% of the original U-235 remaining, and 1.56% has decayed to Pb-207.

Based on the table below, how many half-lives have elapsed since the formation of these crystals?

Percent of U-235 Remaining	Percent Decayed to Pb-207	Half-Lives Elapsed
99.22	0.78	$\frac{1}{64}$
98.44	1.56	$\frac{1}{32}$
96.88	3.12	$\frac{1}{16}$
93.75	6.25	$\frac{1}{8}$
87.50	12.5	$\frac{1}{4}$
75.0	25.0	$\frac{1}{2}$
50.0	50.0	1
37.5	62.5	$1\frac{1}{2}$
25.0	75.0	2
12.5	87.5	3
6.25	93.75	4

6/03

5 A sample of wood found in an ancient tomb contains 25% of its original carbon-14. The age of this wood sample is approximately

- (1) 2,800 years (2) 5,700 years (3) 11,400 years (4) 17,100 years

8/03

27 The table below gives information about the radioactive decay of carbon-14. Part of the table has been deliberately left blank for student use.

Half-life	Mass of Original Carbon-14 Remaining (grams)	Number of Years
0	1	0
1	$\frac{1}{2}$	5,700
2	$\frac{1}{4}$	11,400
3	$\frac{1}{8}$	17,100
4	$\frac{1}{16}$	
5		
6		
7		

After how many years will 1/128 gram of the original carbon-14 remain?

- (1) 22,800 yr (2) 28,500 yr (3) 34,200 yr (4) 39,900 yr

34 The characteristic of the radioactive isotope uranium-238 that makes this isotope useful for accurately dating the age of a rock is the isotope's

- (1) organic origin (2) constant half-life (3) common occurrence in sediments (4) resistance to weathering and erosion

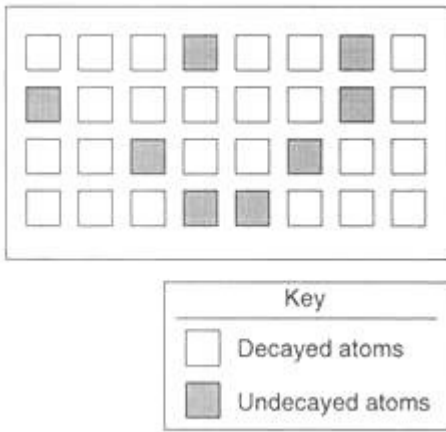
1/02

5 Which radioactive isotope is most useful for determining the age of mastodon bones found in late Pleistocene sediments?

- (1) uranium-238 (2) carbon-14 (3) potassium-40 (4) Iridium-87

6/02

19 The diagram below represents the present number of decayed and undecayed atoms in a sample that was originally 100% radioactive material.



If the half-life of the radioactive material is 1,000 years, what is the age of the sample represented by the diagram?

- (1) 1,000 yr (2) 2,000 yr (3) 3,000 yr (4) 4,000 yr

6/01

25 Carbon-14, an isotope used to date recent organic remains, would most likely be useful in determining the age of a fossil

- (1) trilobite (2) Coelophysis (3) armored fish (4) Beluga whale

8/01

19 The absolute age of a rock is the approximate number of years ago that the rock formed. The absolute age of an igneous rock can best be determined by

- (1) comparing the amounts of decayed and undecayed radioactive isotopes in the rock
- (2) comparing the sizes of the crystals found in the upper and lower parts of the rock
- (3) examining the rock's relative position in a rock outcrop
- (4) examining the environment in which the rock is found