Name Date

Section 7.2 Summary

Half-Life

Textbook pages 302–311

Before You Read

Write a sentence in the lines below explaining what the word decay means to you. As you read about radioactive decay, think about how the common meaning of decay differs from the scientific meaning.

What is radiocarbon dating?

Radiocarbon dating is the process of determining the age of an object by measuring the amount of carbon-14 remaining in that object. Carbon's isotopes include carbon-12 and carbon-14. When an organism is alive, the ratio of carbon-14 atoms to carbon-12 atoms in the organism remains nearly constant. But when an organism dies, its carbon-14 atoms decay without being replaced. The ratio of carbon-14 to carbon-12 then decreases with time. By measuring this ratio, the age of an organism's remains can be estimated. Only material from plants and animals that lived within the past 50 000 years contains enough carbon-14 to be measured using radiocarbon dating.

What is a half-life and how is it used in radiocarbon dating?

A half-life is a measure of the rate of radioactive decay for a given isotope. It is equal to the time required for half the nuclei in a sample to decay. Its value is a constant for any radioactive isotope. For example, the half-life of the radioisotope strontium-90 is 29 years. If you have 10.0 g of strontium-90 today, 29 years from now you will have 5.00 g left. This is because one half-life will have passed ($10.0\ g \times \frac{1}{2} = 5.00\ g$). 58 years from now, two half-lives will have passed and 2.50 g of the sample will remain ($10.0\ g \times \frac{1}{2} \times \frac{1}{2} = 2.50\ g$). The shorter the half-life is, the faster the decay rate. A **decay curve** is a curved line on a graph that shows the rate at which radioisotopes decay.

Mark the Text

In Your Own Words

After you read this section, go back and summarize the main concepts in your own words.

Reading Check

1. Which carbon isotope undergoes radioactive decay?

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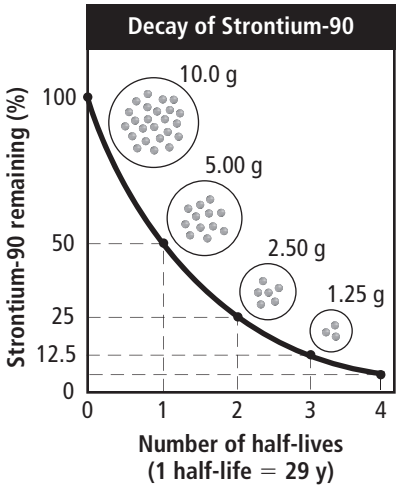

This decay curve shows how the amount of strontium-90 in a sample changes over time.

What are parent and daughter isotopes?

A **parent isotope** is an isotope that undergoes radioactive decay. The stable product of this decay is called the **daughter isotope**. The production of a daughter isotope can be a direct reaction or the result of a series of decays.

Each parent isotope can be paired with a specific daughter isotope. For example, carbon-12 is the daughter isotope of carbon-14 (the parent isotope). The chart on page 307 of the textbook lists other common isotope pairs. It also shows the half-life of the parent and the effective dating range the isotope can be used for. ✔

Reading Check

1. Which isotope decays, the parent or the daughter?

_____

How does the potassium-40 clock work?

The potassium-40 clock uses radioisotopes, specifically potassium-40 and argon-40, to determine Earth's age. Potassium-40 has a half-life of 1.3 billion years. Its daughter isotope is argon-40. When rock is produced from lava, all the gases in the molten rock, including argon-40, are driven out. This process sets the potassium radioisotope clock to zero, because potassium-40 (the parent) is present but no argon-40 (the daughter) is present.

As the molten rock cools over time, it traps gases that form as a result of radioactive decay. When tested, both potassium-40 and argon-40 are now present in the rock. As

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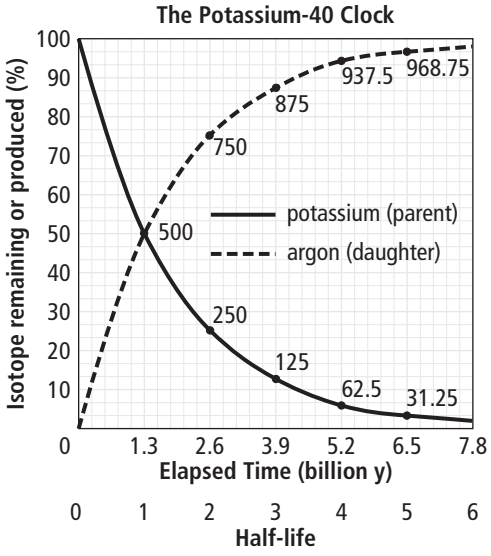
the mass of the parent isotope drops, the mass of the daughter isotope increases. By measuring this ratio, the age of the rock can be estimated. For example, if analysis showed that there were equal masses of potassium-40 and argon-40 in a rock, the rock would be 1.3 billion years old, the amount of time it takes half of the potassium-40 to decay into argon-40.



The solid line shows that the parent isotope is decaying. The dashed line shows that the daughter isotope is being produced.

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Use with textbook pages 302–309.

Radioactive decay

1. Define the following terms.

(a) half-life _____

(b) decay curve _____

(c) parent isotope _____

(d) daughter isotope _____

2. Complete the following tables.

Half-Life	Percent of parent isotope	Percent of daughter isotope
0		
1		
2		
3		
4		

Half-Life	Fraction of parent isotope	Fraction of daughter isotope
0		
1		
2		
3		
4		

3. A rock sample contains 120 g of a radioactive isotope. The radioactive isotope has a half-life of 5 years.

(a) Complete the following table.

Half-Life	Time (a)	Mass (g)
0	0	
1	5	
2	10	
3	15	
4	20	
5	25	

(b) How much of the radioactive isotope if left after 25 years have passed? _____

(c) How many half-lives have passed if there is only 15 g of the parent isotope left?

_____

(d) How many years have passed if there is only 7.5 g of the parent isotope left?

_____

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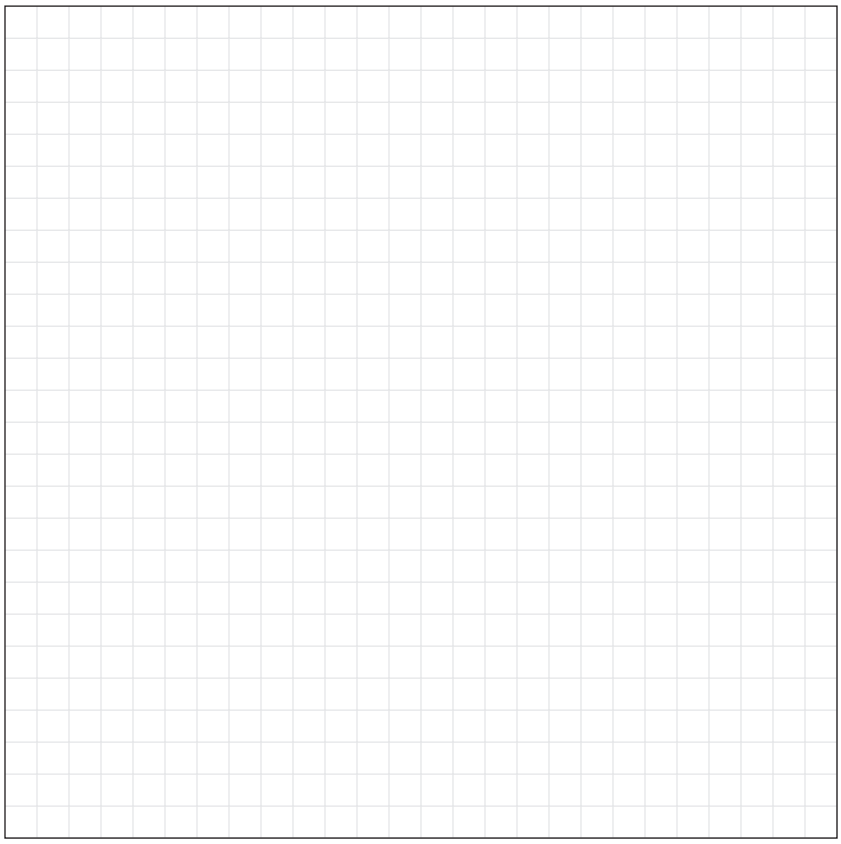
(e) Use the data in the table to graph a decay curve. Label the *x*-axis with Time (a) and the *y*-axis with Mass (g).



4. A rock sample contains 80 g of a radioactive isotope with a half-life of 20 years.

(a) Complete the following table.

Half-Life	Time (a)	Mass of parent isotope (g)	Mass of daughter isotope (g)
0	0		
1	20		
2	40		
3	60		
4	80		
5	100		

(b) How much of the parent isotope is left after 4 half-lives? _____

(c) How much of the parent isotope is left after 100 years? _____

(d) How much of the daughter isotope is present after 60 years? _____

(e) How much time has passed if 77.5 g of the daughter isotope is present? _____

(f) What is the ratio of parent isotope to daughter isotope after 2 half-lives? _____

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Calculating half-life

1. A radioactive isotope has a half-life of 10 minutes.

(a) What fraction of the parent isotope will be left after 30 minutes?

_____

(b) What percent of the parent isotope will be left after 40 minutes?

_____

(c) What fraction of the daughter isotope will be present after 20 minutes?

_____

(d) What percent of the daughter isotope will be present after 50 minutes?

_____

2. A 36 g sample of a radioactive isotope decayed to 4.5 g in 36 minutes. How much of the original parent isotope would remain after the first 12 minutes?

_____

3. The half-life of a particular radioactive isotope is 8 hours. What percent of the parent isotope would remain after 1 day? _____

4. A radioactive isotope sample has a half-life of 4 days. If 6 g of the sample remains unchanged after 12 days, what was the initial mass of the sample?

_____

5. Suppose the ratio of a radioactive parent isotope to a stable daughter isotope within a rock sample is 1:3. The half-life of the parent isotope is 710 million years. How old is the rock sample? _____

6. A rock sample was dated using potassium-40. Measurement indicates that 1/8 of the original parent isotope is left in the rock sample. How old is the rock sample?

_____

7. When a sample of lava solidified, it contained 28 g of uranium-238. If that lava sample was later found to contain only 7 g of U-238, how many years had passed since the lava solidified? _____

8. After 25 years, the number of radioactive cobalt atoms in a sample is reduced to $\frac{1}{32}$ of the original count. What is the half-life of this isotope? _____

9. The half-life of Sr-90 is 28 years. If an 80 g sample of Sr-90 is currently in a sample of soil, how much Sr-90 will be present in the soil 84 years later? _____

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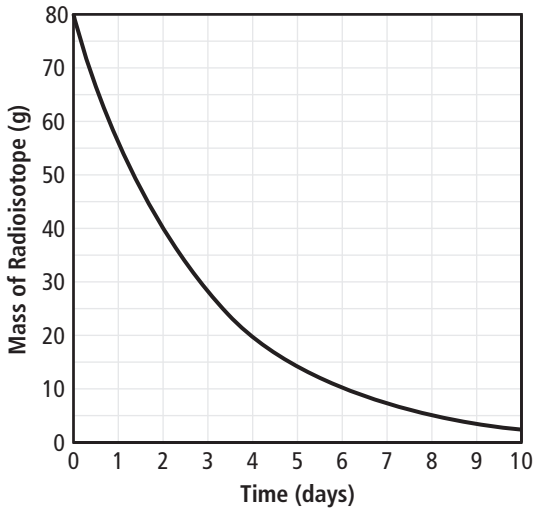
Decay curves



1. Use the decay curve to answer the questions.

(a) What is the half-life of the isotope?

_____

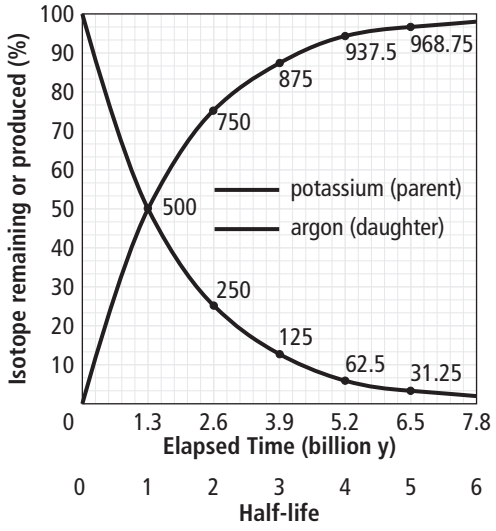
(b) How much of the parent isotope remains after 4 days? _____

(c) How much of the daughter isotope is present after 6 days? _____

(d) What fraction of the parent isotope remains after 8 days? _____

(e) How long does it take for the parent isotope to decay to 5 g? _____

2. Use the decay curve to answer the questions.



(a) What is the common isotope pair for this decay curve? _____

(b) What is the half-life of the parent isotope?

_____

(c) What does the intersection of the two lines represent? _____

(d) What fraction of the daughter isotope is present after 5.2 billion years have passed?

_____

(e) What is the ratio of parent isotope to daughter isotope after 2.6 billion years have passed? _____

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Half-life

Match the Term on the left with the best Descriptor on the right. Each Descriptor may be used only once.

Term	Descriptor
1. _____ half-life **2.** _____ decay curve **3.** _____ parent isotope **4.** _____ daughter isotope	**A.** the stable product of radioactive decay **B.** the isotope that undergoes radioactive decay **C.** a curved line on a graph that shows the rate at which radioisotopes decay **D.** the time required for half the nuclei in a sample of a radioactive isotope to decay

5. Radiocarbon dating can be used to determine the age of which of the following?

I.	a rock sample
II.	the fossil of a fern plant
III.	the skeleton of a dead bear

A. I and II only

B. I and III only

C. II and III only

D. I, II, and III

6. After how many half-lives are there equal amounts of parent and daughter isotopes?

A. 1 **C.** 3

B. 2 **D.** 4

7. The half-life of Ni-28 is six days. What fraction of a sample of this isotope will remain after 18 days?

A. 1/2 **C.** 1/8

B. 1/4 **D.** 1/16

8. The half-life of a particular radioactive isotope is 6 hours. What percent of the daughter isotope would be present after 1 day?

A. 50% **C.** 87.5%

B. 75% **D.** 93.75%

9. A 24 g sample of a radioactive isotope decayed to 1.5 g in 48 minutes. How much of the original parent isotope remained after 24 minutes?

A. 3 g **C.** 12 g

B. 6 g **D.** 18 g

10. A radioactive isotope sample has a half-life of 5 days. If 8 g of the sample remains unchanged after 20 days, what was the initial mass of the sample?

A. 32 g **C.** 128 g

B. 64 g **D.** 256 g

11. If the half-life of an isotope is 8000 years and the amount of that isotope present in an igneous rock is only $\frac{1}{4}$ of the original amount, how old is the rock?

A. 8000 years old

B. 16 000 years old

C. 24 000 years old

D. 32 000 years old

12. What is the advantage of using a radioisotope with a short half-life for medical diagnostic purposes?

A. the radioactivity is easy to monitor

B. the radioactivity lasts for a long time

C. the radioactivity does not stay in the body

D. the radioactivity induced by the radioisotope is stronger

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