DATE: NAME: CLASS:

CHAPTER 7

Half-Life and Radioisotope Dating

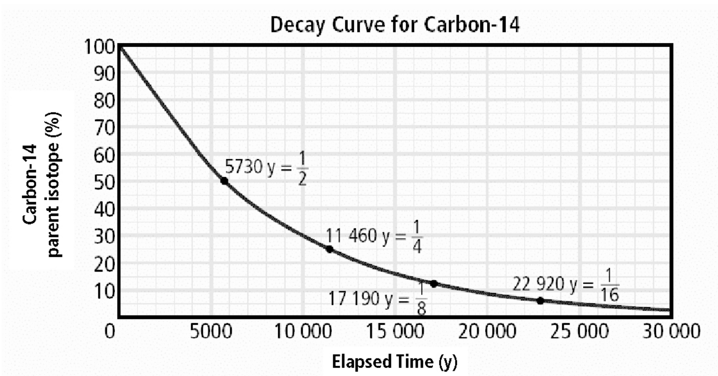
BLM 2-46

Goal • Demonstrate your understanding of the use of half-life in radioisotope dating.

What to Do

Answer the questions in the space provided.

1. Examine the graph showing the decay curve for carbon-14. The graph shows the amount of radioactive carbon-14 that would be in a sample of organic material for 30 000 years after the organism died.



(a) Define half-life.

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(b) How long is one half-life for carbon-14? ____________

(c) What percentage of carbon-14 remains (i) after one half-life? ____________
(ii) after two half-lives? ____________ (iii) after three half-lives? ____________

(d) Use the graph to estimate the percentage of carbon-14 remaining after
(i) 5000 years ________ (ii) 10 000 years ________ (iii) 15 000 years ________.

(e) Use the graph to estimate the number of years that have passed since the organism died if the percentage of parent isotope that remains is
(i) 40% ________ (ii) 20% ________ (iii) 5% ________ .

(f) Explain why carbon-14 half-life measurements are not effective in dating an organism that has been dead for more than 50 000 years.

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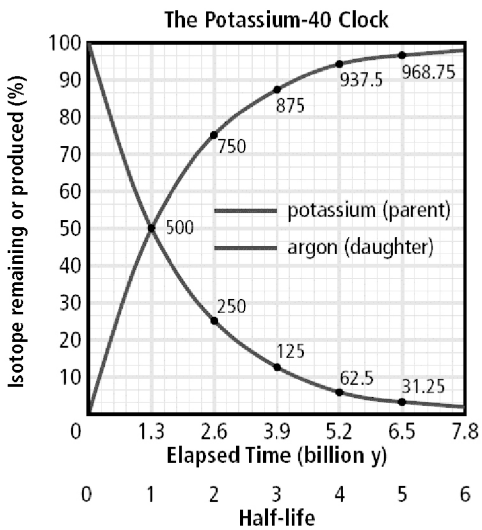
2. Volcanic rocks can be dated using the potassium-40 clock, a dating method based on the decay of the potassium-40 isotope into the argon-40 isotope. Potassium-40 can exist as hot molten rock, whereas argon-40, the daughter isotope, escapes from the molten rock because it is a gas. When the molten rock solidifies, potassium-40 is present, but argon-40 is absent. The age of volcanic rock can be measured by comparing the amount of these two isotopes present in the rock.



(a) Why is there no argon-40 present in the molten rock when it solidifies?

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(b) After many years, argon-40 is present in volcanic rock containing potassium-40, even though no argon-40 was there to begin with. How did the argon-40 get there?

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(c) What is the length, in years, of one half-life of potassium-40? ____________________

(d) Suppose a sample of volcanic rock contained 100 nanograms (a nanogram is a billionth of a gram) of potassium-40 when the rock first formed. How many nanograms of potassium-40 and of argon-40 would be present in the sample after

(i) 1 half-life? ________________

(ii) 2 half-lives? ________________

(iii) 3 half-lives? ________________

3. The table of parent-daughter isotopes shows three different isotope pairs that are used in radioisotope dating. Examine the chart and answer the following questions.

Isotope		Half-Life of Parent (y)	Effective Dating Range (y)
Parent	Daughter		
uranium-235	lead-207	710 million	> 10 million
potassium-40	argon-40	1.3 billion	10 000 to 3 billion
carbon-14	nitrogen-14	5730	up to 50 000

(a) Lead-207 is called the daughter of uranium-235. What does this mean?

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(b) How old is a rock sample that contains uranium-235 and lead-207 in equal amounts?

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(c) The age of Earth was first established in 1953 when Claire C. Patterson of the California Institute of Technology used a uranium-lead clock to analyze rock. In comparing amounts of uranium-235 with lead-207, he established that slightly less than 8 half-lives of uranium-207 had passed since the rock formed. Using this data, estimate the age of Earth.

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(d) The rocks that make up the Canadian shield are extremely old. They are estimated to be between 3.7 and 3.8 billion years. (A billion is a thousand million).

(i) Estimate how many half-lives of uranium-235 would have passed in a sample of rock this old. __________________________

(ii) Estimate the percentage of original uranium that would remain in a sample of rock from the Canadian shield. __________________________

(e) Suppose a sample of rock from the Canadian shield were analyzed using the potassium-40 clock. What information could this give about the age of rock?

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(f) Could carbon-14 dating be used to estimate the age of rocks in the Canadian shield? Explain.

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3. The oxygen isotopes have the same number of electrons and the same number of protons. The number of neutrons does not affect reactivity. How elements form compounds is dictated primarily by the valence electrons.

BLM 2-44, Isotopes

1. D
2. A
3. B
4. C
5. B
6. C

BLM 2-46, Half-Life and Radioisotope Dating

1. (a) Half-life is the time needed for half of a sample of a radioisotope to decay.
   (b) 5730 years
   (c) (i) 50% (ii) 25% (iii) 12.2%
   (d) (i) 55% (ii) 30% (iii) 15%
   (e) (i) 7500 years (ii) 13 000 years (iii) 26 000 years
   (f) After 50 000 years there is insufficient parent isotope remaining to be able to detect it.
2. (a) Potassium-40 can exist hot molten rock, while argon-40, the daughter isotope, escapes from the molten rock because it is a gas.
   (b) By radioactive decay of potassium-40
   (c) 1.3 billion years (or 1300 million years)
   (d) (i) 50 nanograms of potassium and 50 nanograms of argon-40
   (ii) 25 nanograms of potassium and 75 nanograms of argon-40
   (iii) 12.5 nanograms of potassium and 87.5 nanograms of argon-40
3. (a) lead-207 decays into uranium-235
   (b) 710 million years (equivalent to one half-life)
   (c) Estimated age is 5.68 billion years (Claire's analysis gave 5.55 billion years).
   (d) (i) About 5 half-lives (ii) 3.125% remains
   (e) Although the method cannot be used to date rocks older than 3 billion years, the method would still be able to demonstrate that the rocks were at least that age.
   (f) Carbon-14 has a half-life in the hundreds of years and there would be no detectable amount present in the rocks, making carbon-14 dating unable to date the rock.

BLM 2-47, Chapter 7 Quiz

1. A
2. B
3. D
4. D
5. B
6. C
7. C
8. B
9. B
10. C
11. F
12. A
13. D
14. G
15. B