Name _____ Date _____ Class _____

WORKSHEET 36

MATH IN SCIENCE: INTEGRATED SCIENCE

MATH SKILLS USED
Multiplication
Division
Fractions
Decimals
Percentages
Scientific Notation

Radioactive Decay and the Half-life

Use the half-lives of elements to learn about radioactive dating.

Most elements found in nature are stable; they do not change over time. Some elements, however, are unstable—that is, they change into a different element over time. Elements that go through this process of change are called **radioactive**, and the process of transformation is called **radioactive decay.** Because radioactive decay happens very steadily, scientists can use radioactive elements like clocks to measure the passage of time. By looking at how much of a certain element remains in an object and how much of it has decayed, scientists can determine an approximate age for the object.

So why are scientists interested in learning the ages of objects? By looking at very old things, such as rocks and fossils, and determining when they were formed, scientists learn about the history of the Earth and the plants and animals that have lived here. Radioactive dating makes this history lesson possible! A **half-life** is the time that it takes for half a certain amount of a radioactive material to decay, and it can range from less than a second to billions of years. The chart below lists the half-lives of some radioactive elements.

Table of Half-lives

Element	Half-life
Bismuth-212	60.5 minutes
Carbon-14	5730 years
Chlorine-36	400,000 years
Cobalt-60	5.26 years
Iodine-131	8.07 days

Element	Half-life
Phosphorous-24	14.3 days
Polonium-215	0.0018 seconds
Radium-226	1600 years
Sodium-24	15 hours
Uranium-238	4.5 billion years

1. Use the data in the table above to complete the following chart:

Table of Remaining Radium

Number of years after formation	0	1600	3200	6400	12,800
Percent of radium-226 remaining	100%	50%			

2. If 1 g of sodium-24 has decayed from a sample that was originally 2 g, how old is the sample?

_____

_____

3. What fraction of chlorine-36 remains undecayed after 200,000 years?

_____

_____

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Radioactive Decay and the Half-life, continued

4. As uranium-238 decays, it becomes lead-206. After 3.5 g of uranium-238 decays for 1.125×10^9 years, how many grams of the sample will be lead-206?

5. A scientist has a 2.5 g sample of radium-226. How many grams of the sample will decay in 800 years?

6. An archaeologist finds a piece of old bone that she believes may be 2000 years old. The lab technician tells her that the carbon-14 in the bone has completed 25 percent of its first half-life. Does this finding support her belief about the age of the bone? Why or why not?

7. A technician does a test on an unidentified radioactive element and discovers that it has a half-life of 4.5×10^9 years. What element do you think it is, and why?

8. A paleontologist unearths the remains of a *Tyrannosaurus rex*. We know that these dinosaurs became extinct about 65 million years ago. Therefore, would it be reasonable to expect that the carbon-14 in the fossil has completed 15,000 half-lives? Why or why not?

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So why are scientists interested in learning the ages of objects? By looking at very old things, such as rocks and fossils, and determining when they were formed, scientists learn about the history of the Earth and the plants and animals that have lived here. Radioactive dating makes this history lesson possible! A **half-life** is the time that it takes for half a certain amount of a radioactive material to decay, and it can range from less than a second to billions of years. The chart below lists the half-lives of some radioactive elements.

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Sodium-24	15 hours
Uranium-238	4.5 billion years

1. Use the data in the table above to complete the following chart:

Table of Remaining Radium

Number of years after formation	0	1600	3200	6400	12,800
Percent of radium-226 remaining	100%	50%	25%	12.5%	6.25%

2. If 1 g of sodium-24 has decayed from a sample that was originally 2 g, how old is the sample?

Because half of the sample has decayed, we know that one half-life has passed, which is 15 hours.

The sample is 15 hours old.

3. What fraction of chlorine-36 remains undecayed after 200,000 years?

200,000 is one-half of 400,000, so one-half of the half-life has passed. Therefore, one-quarter of the sample has decayed, leaving three-quarters of the sample undecayed.

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Radioactive Decay and the Half-life, continued

4. As uranium-238 decays, it becomes lead-206. After 3.5 g of uranium-238 decays for 1.125×10^9 years, how many grams of the sample will be lead-206?

$(1.125 \times 10^9) \div (4.5 \times 10^9) = 0.25$ of the half-life has passed. Therefore, 0.125 g of the sample has decayed. $0.125 \times 3.5 = 0.438$; 0.438 g of the sample has decayed into lead-206.

5. A scientist has a 2.5 g sample of radium-226. How many grams of the sample will decay in 800 years?

$800 \div 1600 = 0.5$; 0.5 of the half-life passes in 800 years. Therefore, 0.25 of the sample decays in this time. $0.25 \times 2.5 = 0.625$ g of radium-226 will decay in 800 years.

6. An archaeologist finds a piece of old bone that she believes may be 2000 years old. The lab technician tells her that the carbon-14 in the bone has completed 25 percent of its first half-life. Does this finding support her belief about the age of the bone? Why or why not?

25% of the half-life of carbon-14 is 0.25×5730 years = 1432.5 years; Because the bone is less than 2000 years old, this finding does not support her belief.

7. A technician does a test on an unidentified radioactive element and discovers that it has a half-life of 4.5×10^9 years. What element do you think it is, and why?

4.5×10^9 years is 4.5 billion years; The substance may be uranium-238, which has the same half-life.

8. A paleontologist unearths the remains of a *Tyrannosaurus rex*. We know that these dinosaurs became extinct about 65 million years ago. Therefore, would it be reasonable to expect that the carbon-14 in the fossil has completed 15,000 half-lives? Why or why not?

$15{,}000 \times 5730 = 85{,}950{,}000$ years; Yes, it would be reasonable because the *T. rex* had not yet become extinct 85 million years ago.

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