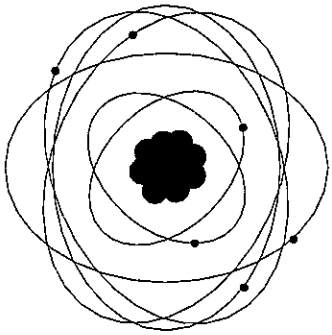
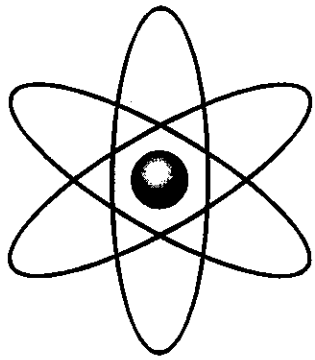
Radioactive Decay Data



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



Overview:

Radioactive elements release nuclear particles called alpha and beta particles and energy in the form of gamma rays. When these particles are released from the nucleus of a radioactive atom, the element changes, becoming a different element. This is called radioactive disintegration. Knowing the half-life (the time it takes for half of the radioactive element to disintegrate) scientists have developed methods to date objects containing a radioactive element. Each radioactive element has its own unique half-life, which is constant, and cannot be changed by environmental influences such as heat and pressure. By using the known half-life of a radioactive element, scientists can date objects. Radioactive dating is our basis for the geologic timeline.

The Chart:

This chart shows 4 radioactive isotopes. These are radioactive elements that, over time, will decay and eventually change into different non-radioactive stable element(s). In the Disintegration column, it shows the radioactive element's symbol and the non-radioactive element's symbol(s) it would eventually decay, or disintegrate, into. As shown, radioactive carbon-14 will change into non-radioactive nitrogen-14. The time it takes for half of a radioactive element to decay into its decay product is called its half-life. For example, if we start with a 100% radioactive C-14 sample, after the 1st half-life 50% is still radioactive and 50% is non-radioactive and 5,700 years have passed. After the 2nd half-life, 25% is C-14 and 75% is N-14 and 11,400 years have passed (5,700 yr + 5,700 yr). This process continues until the radioactive element has completely changed into the non-radioactive substance.

Additional Information:

- In a radioactive element, radiation gets weaker in time, but the half-life stays the same.
- Carbon-14 is found in organic substances, such as bones, wood and shells and has a relatively short half-life compared to the other 3 given elements in the above chart.
- Carbon-14 is used to date relatively young organic substances, less than 100,000 years old. Thus dinosaur bones, being millions of years in age, are too old to be dated using C-14.
- Uraniuim-238 has a half-life of 4.5×10^9 years, which equals 4.5 billion years (10^9 = billion).
- Uraniuim-238 is used to date very old (billions of years) inorganic substances, such as rocks and meteorites. This radioactive element was used to arrive at the Earth's age.
- On a graph the radioactive substance decreases from 100% moving downward toward 0%, while the non-radioactive element increases from 0%, moving upward toward 100%.

Set 1 — Radioactive Decay Data

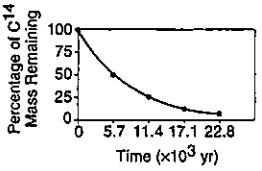
1. Radioactive carbon-14 dating has determined that a fossil is 5.7×10^3 years old. What is the total amount of the original C^{14} still present in the fossil?

   (1) 0% (3) 50%
   (2) 25% (4) 75% 1 _____

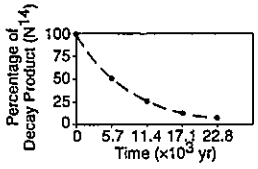
2. A sample of wood found in an ancient tomb contains 25% of its original carbon-14. The age of this wood sample is approximately

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

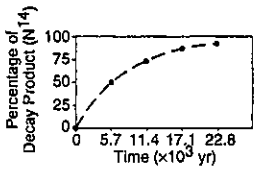
3. A graph of the radioactive decay of carbon-14 is shown to the right.



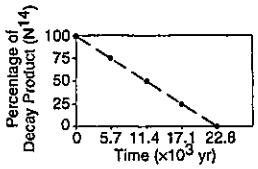
   Which graph correctly shows the accumulation of nitrogen-14, the decay product of carbon-14,over the same period?



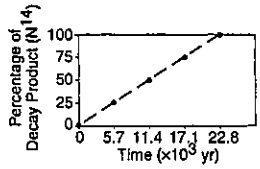
(1)



(3)



(2)



(4) 3 _____

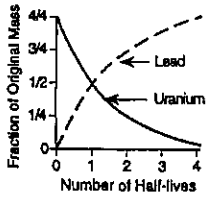
4. The absolute age of a rock is the approximate number of years ago that the rock formed. The absolute age of an igneous rock can best be determined by

   (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 4 _____

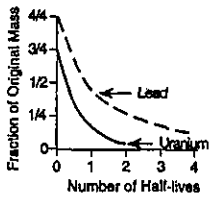
5. An archeologist found an ancient skeleton estimated to be 10,000 to 25,000 years old. Which radioactive isotope would be most useful for finding the age of the skeleton?

   (1) carbon-14
   (2) potassium-40
   (3) uranium-238
   (4) rubidium-87 5 _____

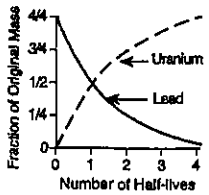
6. Which graph best represents the radioactive decay of uranium-238 into lead-206?



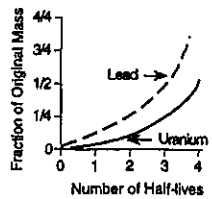
(1)



(3)



(2)



(4) 6 _____

7. The table belows gives information about the radioactive decay of carbon-14. [Part of the table has been left blank for student use.]

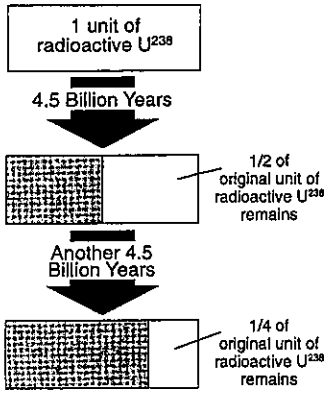
Half-Life	Mass of Original C-14 Remaining (grams)	Number of Years
0	1	0
1	$\frac{1}{2}$	5,700
2	$\frac{1}{4}$	11,400
3	$\frac{1}{8}$	17,100
4		
5		
6		

What is the amount of the original carbon-14 remaining after 34,200 years?

(1) $\frac{1}{8}$ (3) $\frac{1}{32}$

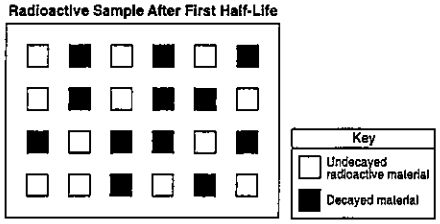
(2) $\frac{1}{16}$ (4) $\frac{1}{64}$ 7 _____

8. The diagram below represents the radioactive decay of uranium-238. Shaded areas on the diagram represent the amount of



(1) undecayed radioactive uranium-238 (U238)
(2) undecayed radioactive rubidium-87 (Rb87)
(3) stable carbon-14 (C14)
(4) stable lead-206 (Pb206) 8 _____

9. Base your answer from 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.



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

(1) 12 (3) 3
(2) 6 (4) 0 9 _____

10. Which process could be indicated by the expression below?

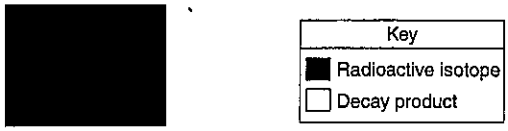
$$U^{238} \rightarrow Pb^{206}$$

(1) crystallization of minerals in basalt
(2) chemical weathering of marble
(3) radioactive decay in granite
(4) ozone depletion in the atmosphere

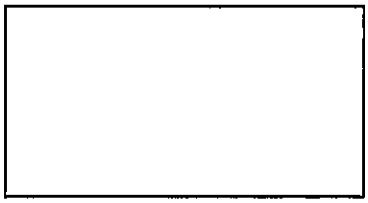
10 _____

11. Base your answer from the diagram below, which represents a sample of a radioactive isotope.

Sample before decay



In the box below shade in the percentage of the radioactive isotope sample that will remain after 2 half-lives.

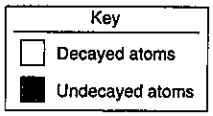


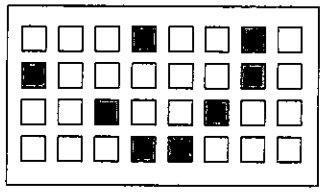
Set 2 — Radioactive Decay Data

12. A sample of wood that originally contained 100 grams of carbon-14 now contains only 25 grams of carbon-14. Approximately how many years ago was this sample part of a living tree?

(1) 2,850 yr (3) 11,400 yr
(2) 5,700 yr (4) 17,100 yr 12 ____

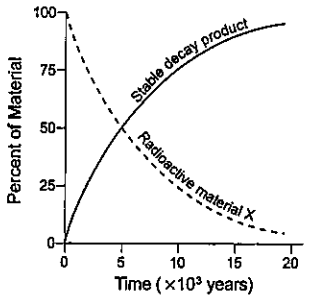
13. The diagram below represents the present number of decayed and undecayed atoms in a sample that was originally 100% radioactive material. If the half-life of the radioactive material is 1,000 years, what is the age of the sample represented by the diagram?





(1) 1,000 yr (3) 3,000 yr
(2) 2,000 yr (4) 4,000 yr 13 ____

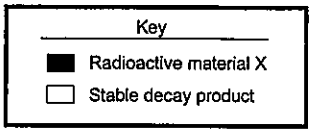
Base your answers to questions 14 through 16 from the accompanying graph, and your knowledge of Earth science. The graph represents the decay of radioactive material **X** into a stable decay product.



14. What is the approximate half-life of radioactive material **X**?

(1) 5,000 yr (3) 50,000 yr
(2) 10,000 yr (4) 100,000 yr 14 ____

15. Which graph best represents the relative percentages of radioactive material **X** and its stable decay product after 15,000 years?



(1) (2) (3) (4) 15 ____

16. Each of the objects below has different amounts remaining of the original radioactive material **X**. Which object is most likely the oldest?

Coal
10% of the radioactive material remains
(1)

Shell
41% of the radioactive material remains
(2)

Wood
33% of the radioactive material remains
(3)

Bone
52% of the radioactive material remains
(4)

16 ____

17. A student filled a graduated cylinder with 1,000 milliliters of water to represent a radioactive substance. After 30 seconds, the student poured out one-half of the water in the cylinder to represent the decay occurring within the first half-life. The student repeated the process every 30 seconds. How much water did the student pour from the cylinder at the 2-minute mark?

(1) 12.5 mL (2) 62.5 mL (3) 125.0 mL (4) 250.0 mL 17 _____

18. State *one* difference between dating objects with the radioactive isotope carbon-14 (C^{14}) and dating objects with the radioactive isotope uranium-238 (U^{238}).

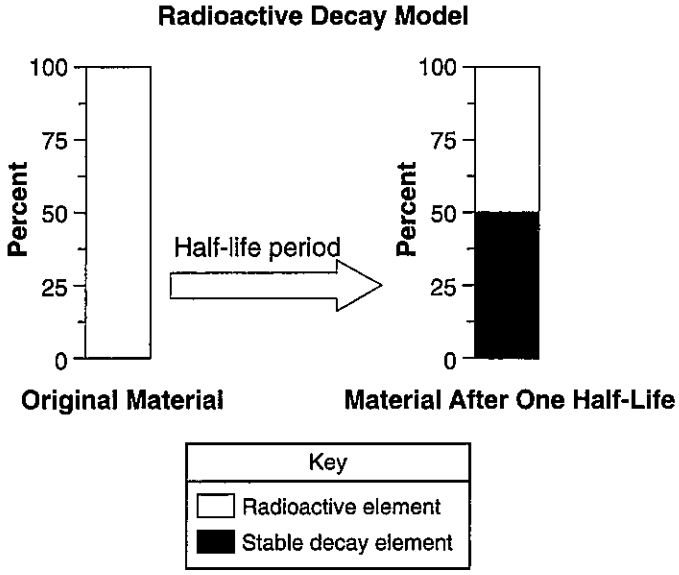
_____

_____

_____

_____

Base your answers to questions 19 through 21 on the accompanying diagram, which represents a model of a radioactive decay of a particular element. The diagram shows the decay of a radioactive element (□) into the stable decay element (■) after one half-life period.



19. If the radioactive element in this model is carbon-14, how much time will have passed after one half-life?

_____years

20. If the radioactive element in this model is uranium-238, how much time will have passed after one half-life? _____years

21. On the Radioactive Decay Model above, shade in the amount of stable decay element present after the second half-life period.