Guided Notes

Geologic History

Relative Age
Sequence of Events
Correlation Techniques
Volcanic Ash Markers
Index Fossils
Geologic Time Scale
Evolution
Radioactive Dating

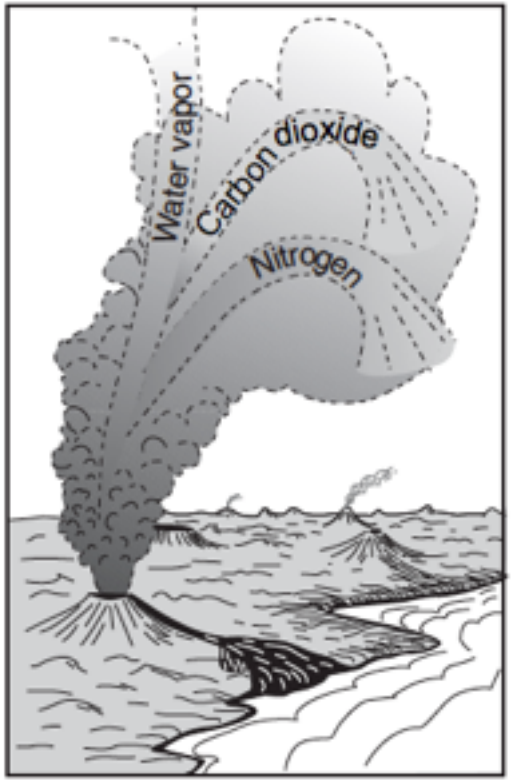
9) How has Earth changed over time?

- **<u>Evolution</u>: change from simple forms to more complex forms**

9) How has Earth changed over time?

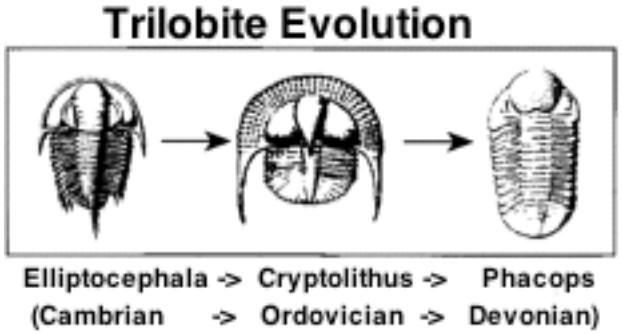
- **Evolution of Earth's Atmosphere:**

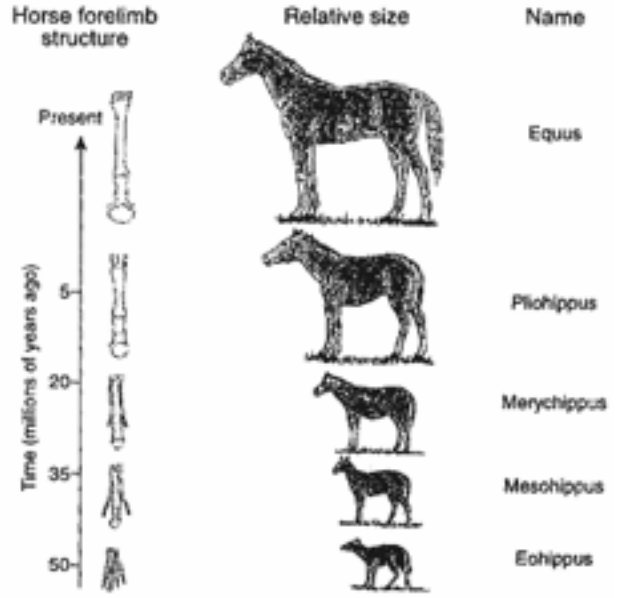
1. **<u>Outgassing</u>: Volcanoes began releasing water vapor, carbon dioxide and nitrogen on early Earth.**
2. **<u>Photosynthesis</u>: With carbon dioxide in the atmosphere, photosynthetic organisms were able to evolve.**
3. **Photosynthesis removed carbon dioxide from the atmosphere and released oxygen.**
4. **Oxygen led to the evolution of most life forms that exist today.**



9) How has Earth changed over time?

- **Evolution of Organisms:**
  - **Fossil record supports the change from simple to complex life forms.**





9) How has Earth changed over time?

- **Extinction**: **end of a species**
  - Most life forms that existed on Earth have become **extinct**.
  - Mass extinction of the dinosaurs **65.5** million years ago:
    - Large craters from **asteroids** found on Earth support the hypothesis that impact events have caused mass extinctions of life forms and global climate changes.

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10) How do scientists give events or fossils an exact age?

- **Radioactive decay** can be used to give an absolute age (age in years) to a material.

10) How do scientists give events or fossils an exact age?

- **<u>Isotope</u>: atoms of the same element that have different numbers of neutrons**

Example: C^{12} and C^{14} are both carbon atoms, but they are isotopes because C^{14} has 2 extra neutrons

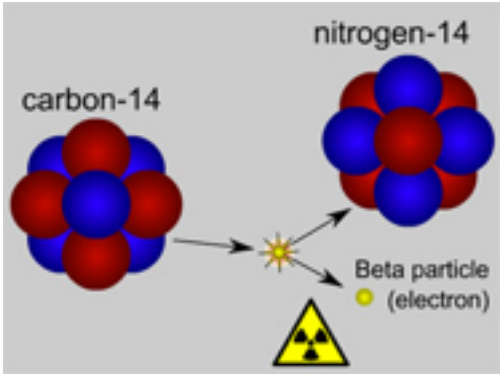
carbon-12
98.9%
6 protons
6 neutrons

carbon-14
<0.1%
6 protons
8 neutrons

10) How do scientists give events or fossils an exact age?

- **<u>Radioactive Decay</u>**: **an unstable radioactive isotope will break down into another more stable element called a decay product.**

Example: C^{14} will decay into N^{14}

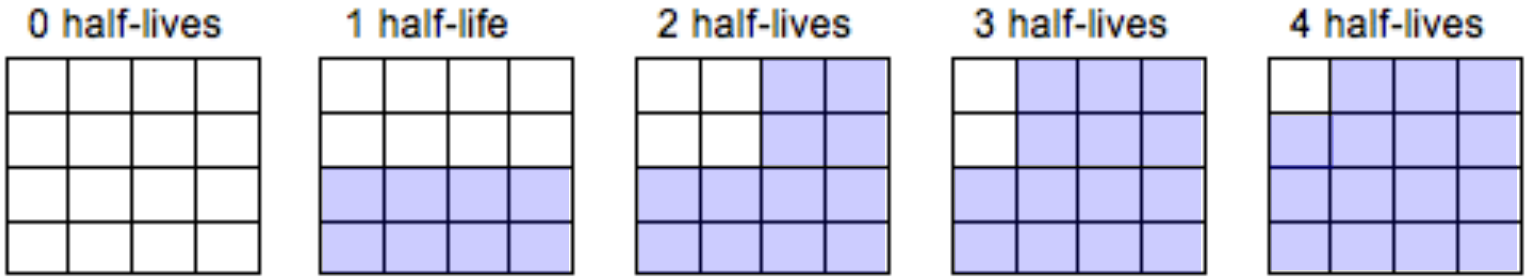


10) How do scientists give events or fossils an exact age?

- **Each radioactive isotope has a known rate of decay that can be used to determine age.**
  - **Half-life: the amount of time it takes for HALF of the atoms in a radioactive sample to decay**
  - **The half-life will never change (even if you apply heat, pressure, break the substance into pieces, etc.)**
  - **Each time one half-life passes; you divide the amount of radioactive substance remaining in half.**

10) How do scientists give events or fossils an exact age?

- **Visualizing Half-Lives:** As radioactive decay progresses, the amount of the radioactive element decreases by half each half-life. The amount of decay product increases by half each half-life. On the diagram below, show the amount of radioactive element (white) compared to decay product (shaded) after each half-life passes. Under each box, indicate the percentage of radioactive element and the percentage of decay product for that half-life.



	0 half-lives	1 half-life	2 half-lives	3 half-lives	4 half-lives
Radioactive Element:	100 %	50 %	25 %	12.5 %	6.25 %
Decay Product:	0 %	50 %	75 %	87.5 %	93.75 %

10) How do scientists give events or fossils an exact age?

- **Note**: **a radioactive sample will never get to zero, because you can always divide the amount remaining in half. (even if it gets really, really small!)**

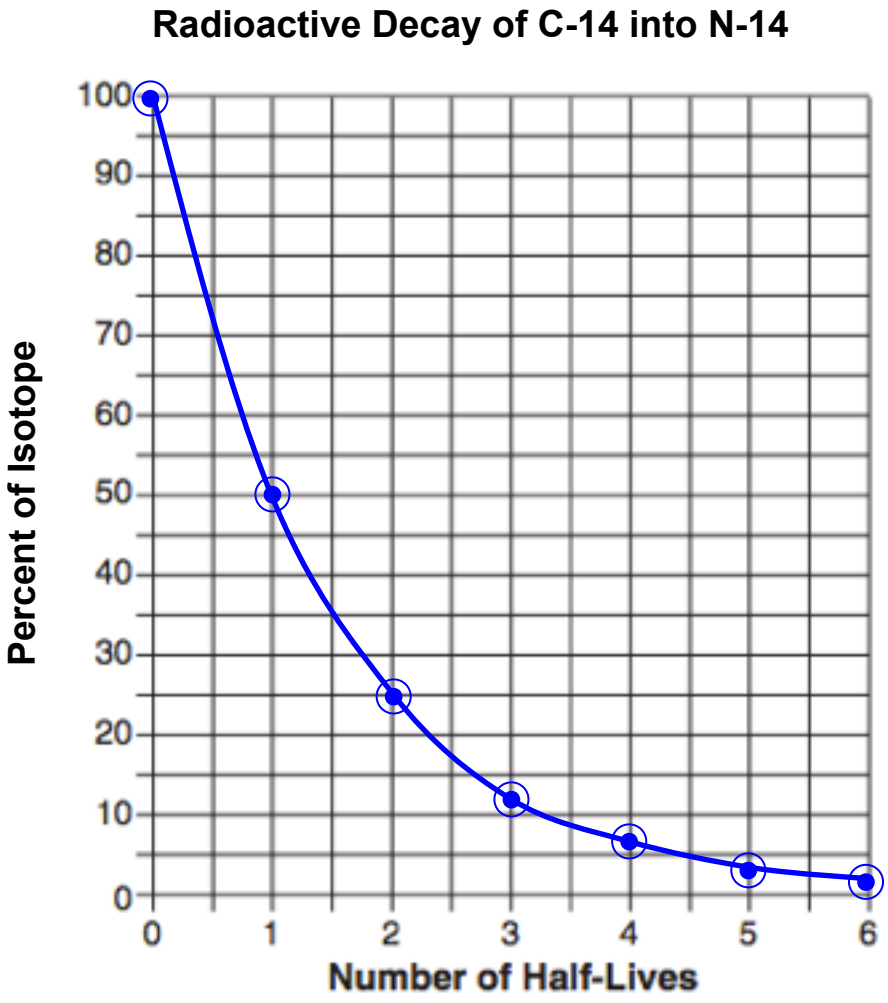
Graphing Half-Lives: The data table below shows the radioactive decay of carbon-14 into its decay product nitrogen-14.

Number of Half-Lives	Percentage of Carbon-14	Percentage of Nitrogen-14
0	100	0
1	50	50
2	25	75
3	12.5	87.5
4	6.3	93.7
5	3.1	96.9
6	1.6	98.4

1) Using the information on the table above, construct a line graph by following the directions below:

a. Plot the data for carbon-14 percentage on your graph. Surround each point with a small circle and connect the points.

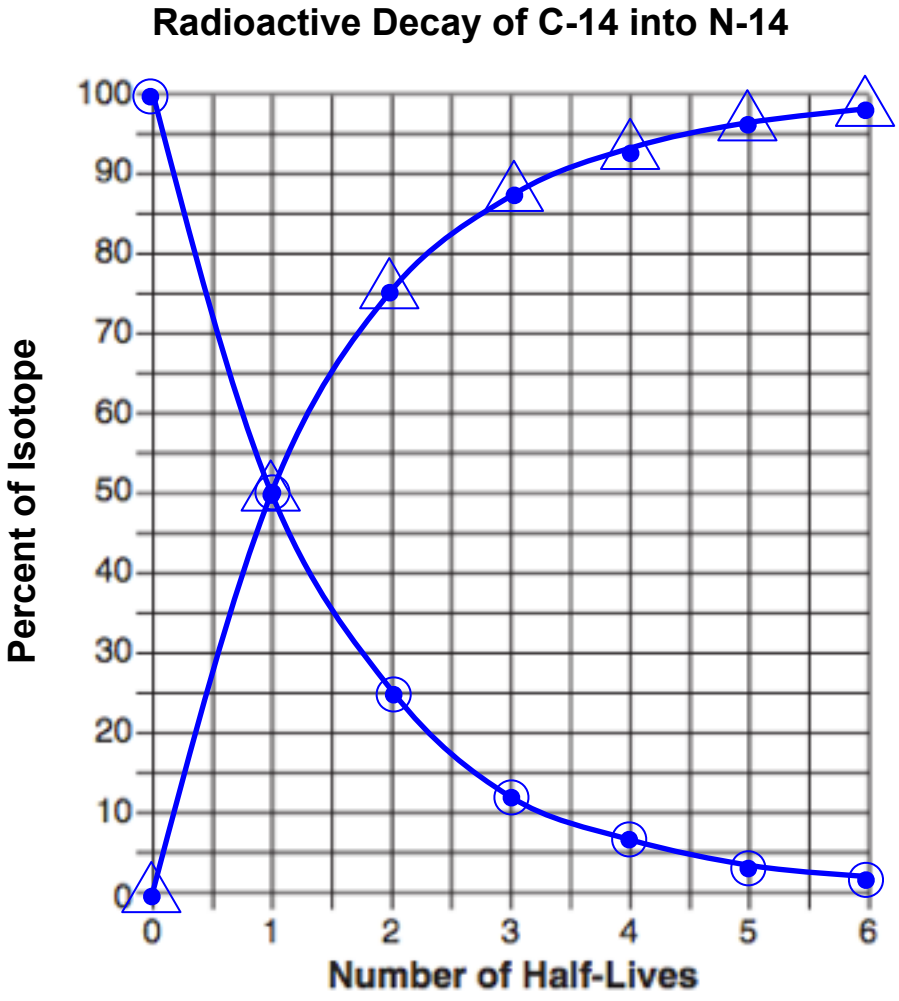
Number of Half-Lives	Percentage of Carbon-14	Percentage of Nitrogen-14
0	100	0
1	50	50
2	25	75
3	12.5	87.5
4	6.3	93.7
5	3.1	96.9
6	1.6	98.4



1) Using the information on the table above, construct a line graph by following the directions below:

b. Plot the data for nitrogen-14 percentage on your graph. Surround each point with a small triangle and connect the points.

Number of Half-Lives	Percentage of Carbon-14	Percentage of Nitrogen-14
0	100	0
1	50	50
2	25	75
3	12.5	87.5
4	6.3	93.7
5	3.1	96.9
6	1.6	98.4



10) How do scientists give events or fossils an exact age?

Different radioactive substances have different half-lives. (ESRT page 1)

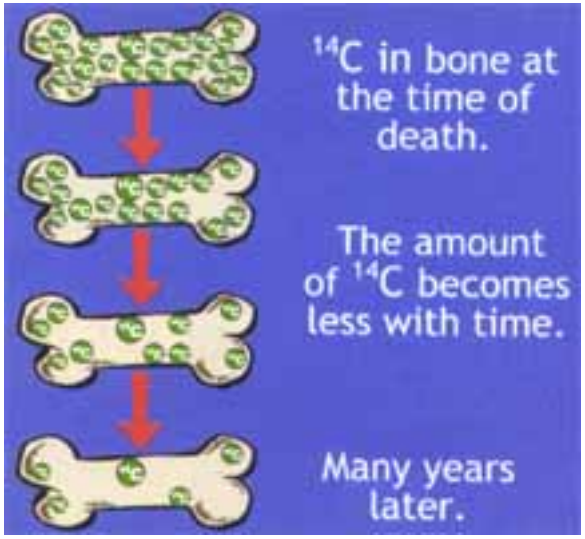
Radioactive Decay Data

RADIOACTIVE ISOTOPE	DISINTEGRATION	HALF-LIFE (years)
Carbon-14	$^{14}C \rightarrow {}^{14}N$	5.7×10^3
Potassium-40	$^{40}K \rightarrow {}^{40}Ar$ and $^{40}K \rightarrow {}^{40}Ca$	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}

10) How do scientists give events or fossils an exact age?

- Short half-life: **Carbon 14** = **5,700** years

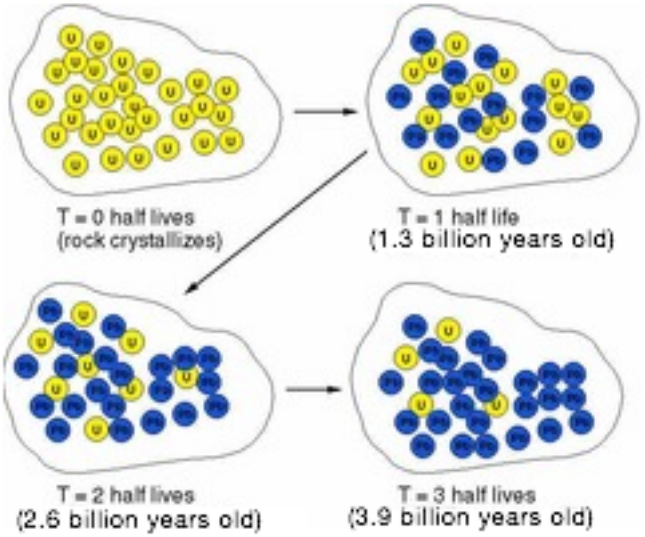
  - **Used to determine the age of "recent" fossils (from the past 50,000 years)**



10) How do scientists give events or fossils an exact age?

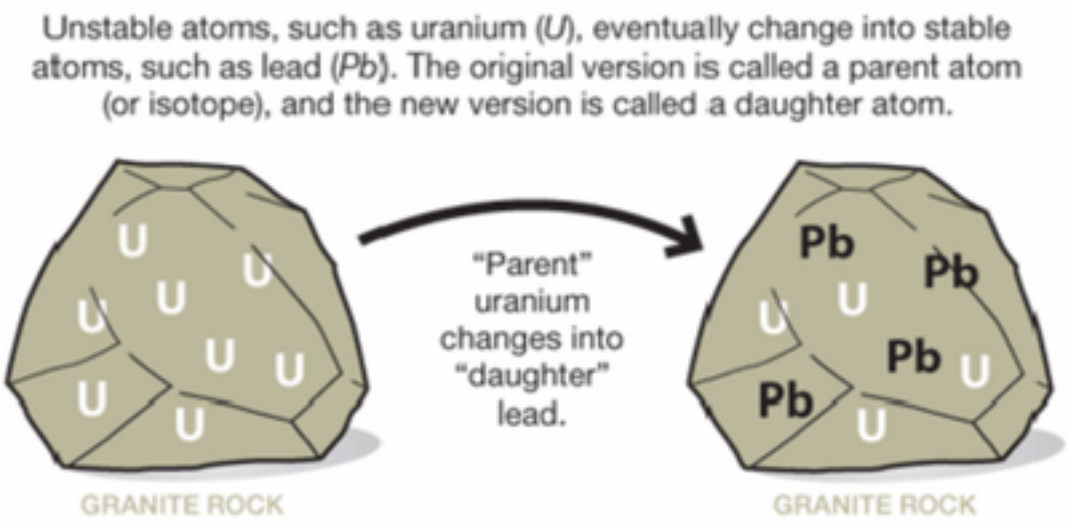
- Long half-life: **Potassium-40** =
  1.3 x 10^9 (1.3 billion) years

  - **Used to determine the age of "old" fossil and rocks**



10) How do scientists give events or fossils an exact age?

- Long half-life: **Uranium 238** = **4.5 x 10^9 (4.5 billion)** years
  - **Used to determine the age of our Earth and solar system**



10) How do scientists give events or fossils an exact age?

Practice Radioactive Decay: Complete the following charts using ESRT page 1:

- **Step 1:** Set up a table with three columns: number of half-life, percent (or fraction) of radioactive element remaining, and age.
- **Step 2:** Fill in the table to at least 4 half-lives for the radioactive element you were given.
- **Step 3:** Use the table to help you answer your question.

10) How do scientists give events or fossils an exact age?

- **Example 1:** A human bone fossil was found to have 12.5% of the original amount of carbon-14 remaining. What is the approximate age of this bone?

# of Half-Lives	% of Carbon-14 remaining	Age (in years)
0	100%	0
1	50%	5,700 years
2	25%	11,400 years
3	12.5%	17,100 years
4	6.25%	22,800 years

10) How do scientists give events or fossils an exact age?

- **Example 2:** An igneous rock was found to have one-fourth of the amount of potassium-40 that it originally contained. What is the age of this rock sample?

# of Half-Lives	% of Carbon-14 remaining	Age (in years)
0	100%	0
1	50%	1.3×10^9 yr
2	25%	2.6×10^9 yr
3	12.5%	3.9×10^9 yr
4	6.25%	5.2×10^9 yr

✓ Checkpoint – Radioactive Decay

1) 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? Show your work by creating a table.

# of Half-Lives	% of Carbon-14 remaining	Age (in years)
0	100%	0

✓ Checkpoint – Radioactive Decay

2) 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

a. organic origin

b. constant half-life

c. common occurrence in sediments

d. resistance to weathering and erosion

✓ Checkpoint – Radioactive Decay

3) Which radioactive element would a scientist most likely have used to date the age of a fossil that is 10,000 years old?

a. potassium-40

b. carbon-14

c. uranium-238

d. rubidium-87

✓ Checkpoint – Radioactive Decay

4) An igneous rock contains 10 grams of radioactive potassium-40 and a total of 10 grams of its decay products. During which geologic time interval was this rock most likely formed?

a. Middle Archean

b. Late Archean

c. Middle Proterozoic

d. Late Proterozoic

# of Half-Lives	% of Carbon-14 remaining	Age (in years)
0	100%	0

✓ Checkpoint – Radioactive Decay

4) An igneous rock contains 10 grams of radioactive potassium-40 and a total of 10 grams of its decay products. During which geologic time interval was this rock most likely formed?

a. Middle Archean

b. Late Archean

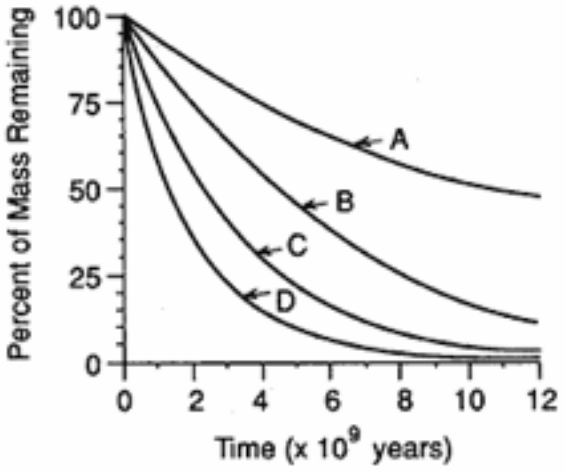
c. Middle Proterozoic

d. Late Proterozoic

# of Half-Lives	% of Carbon-14 remaining	Age (in years)
0	100%	0
1	50%	1.3×10^9 yr
2	25%	2.6×10^9 yr
3	12.5%	3.9×10^9 yr
4	6.25%	5.2×10^9 yr

✓ Checkpoint – Radioactive Decay

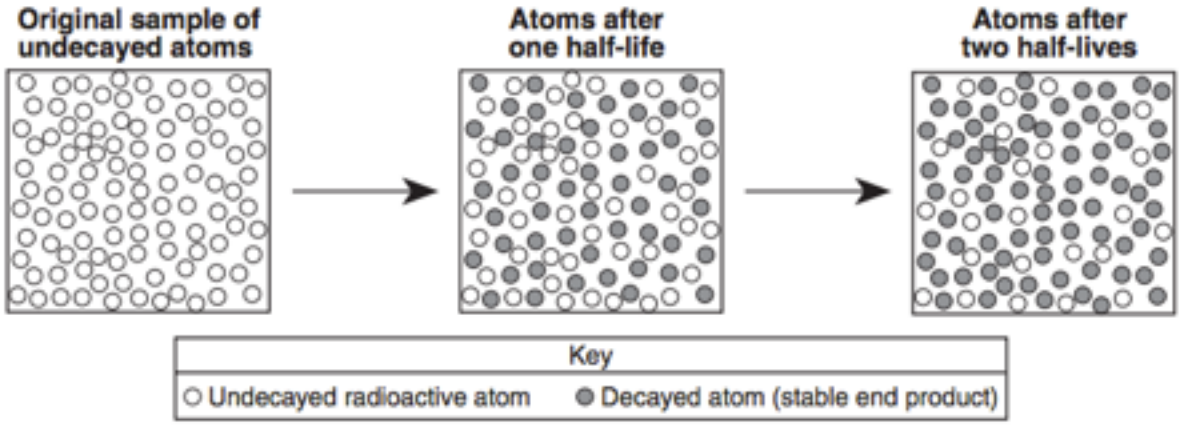
5) The graph below shows the relationship between mass and time for four radioactive elements during radioactive decay.



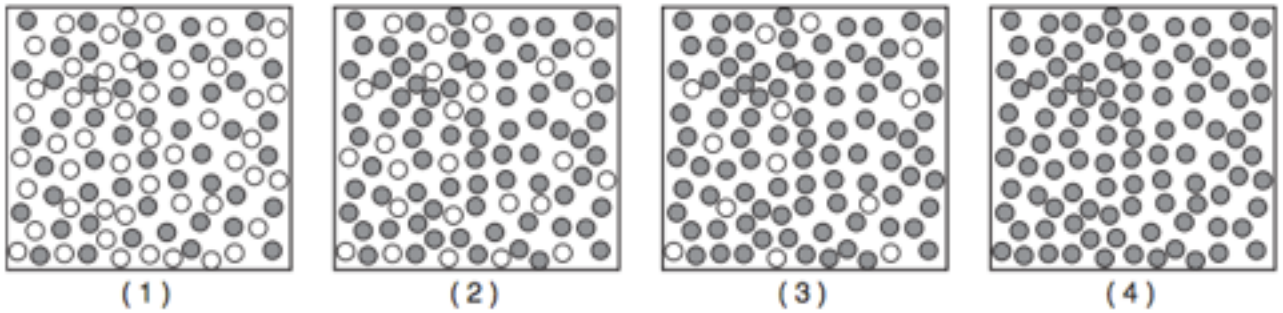
Which line best represents the decay curve for potassium-40? _____

✓ Checkpoint – Radioactive Decay

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

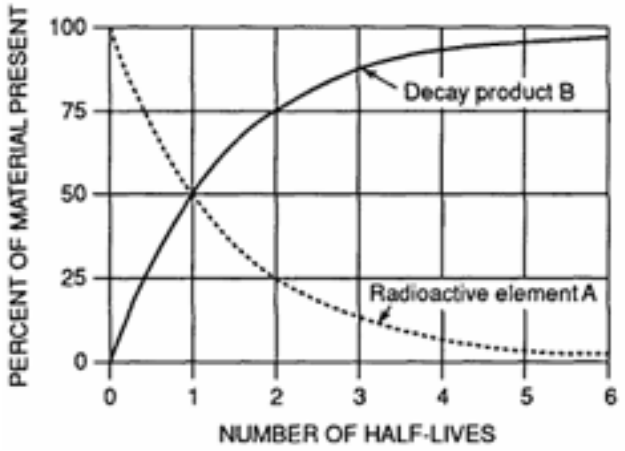


Which model best represents the number of undecayed and decayed atoms after three half-lives?



✓ Checkpoint – Radioactive Decay

7) Base your answer on the graph below which shows the rate of radioactive decay of element A and the rate at which decay product B is formed.



If the radioactive element in a rock sample is potassium-40, which resulting decay product would be present?

a. Sr-87 b. Ar-40 c. N-14 d. C-12