5.2 Half-life & Radioactive Dating

How Does Radiocarbon Dating Work? - Instant Egghead #28
How Does Radiocarbon Dating Work?

Radioactive Dating: carbon-14
- Living organisms contain constant amounts of carbon-14.
- When they die, the carbon-14 begins to decay into nitrogen-14 with a half-life of 5730 years.
- By analyzing how much carbon-14 remains in a sample compared to how much carbon-12, you can accurately date the organism’s death.
- After 50,000 years so little carbon-14 remains that dating becomes impossible.

Decay Curve for Carbon-14:
How much of an 80 g sample of carbon-14 would be left after 15,000 years?
- 1 half-life → 40 g
- 2 half-lives → 20 g
- 3 half-lives → 10 g

Radioactive Dating: potassium-40 clock
- When a sample of potassium-40 cools it contains a certain amount of radioactive potassium-40.
- Over time the potassium-40 decays into argon-40, with a half-life of 1.3 billion years.
- The formation of these rocks can be dated by sampling the ratio of the two isotopes.
- Other isotope pairs allow us to accurately date rocks that are younger or older.

COMMON ISOTOPE PAIRS CHART

<table>
<thead>
<tr>
<th>Isotope</th>
<th>Parent</th>
<th>Daughter</th>
<th>Half-life of Parent (years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon-14</td>
<td>Nitrogen-14</td>
<td>5730</td>
<td></td>
</tr>
<tr>
<td>Uranium-235</td>
<td>Lead-207</td>
<td>710 million</td>
<td></td>
</tr>
<tr>
<td>Potassium-40</td>
<td>Argon-40</td>
<td>1.3 billion</td>
<td></td>
</tr>
<tr>
<td>Uranium-238</td>
<td>Lead-206</td>
<td>4.5 billion</td>
<td></td>
</tr>
<tr>
<td>Thorium-235</td>
<td>Lead-208</td>
<td>14 billion</td>
<td></td>
</tr>
<tr>
<td>Rubidium-87</td>
<td>Strontium-87</td>
<td>47 billion</td>
<td></td>
</tr>
</tbody>
</table>

RADIOACTIVITY SYMBOLS

\[ ^{4}_2\text{He}, ^{4}_2\text{He} \]
\[ ^{0}_{-1}\beta, ^{0}_{-1}\beta \]
\[ ^{0}_{-1}\nu, ^{0}_{-1}\nu \]

Solving Half-Life Problems
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- Half-life problems involve three variables:
  1. Number of Half lives of the parent isotope (0, 1, 2, etc.)
  2. Time elapsed (hours, days, years)
  3. Amount of the parent isotope remaining (g, kg, or %)

- A half-life problem will identify two of the three, you will need to calculate the third.
- Make sure that you ALWAYS start at 0 for half-life and time, and at 100% for the amount of the parent isotope.

\[\text{Remember:} \quad \% \text{ Parent} + \% \text{ Daughter} = 100\%\]

<table>
<thead>
<tr>
<th>Half-Life</th>
<th>Time</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>100%</td>
</tr>
<tr>
<td>1</td>
<td>1 half-life</td>
<td>50%</td>
</tr>
<tr>
<td>2</td>
<td>2 half-life</td>
<td>25%</td>
</tr>
<tr>
<td>3</td>
<td>3 half-lives</td>
<td>12.5%</td>
</tr>
</tbody>
</table>

Practice: If 50 grams of carbon-14 were present in a sample of bone, state how many grams would be left after 17,190 years?

From the data table, the half-life of carbon-14 is 5730 years.

\[
\begin{align*}
\text{Half-life} & \quad \text{Time (years)} & \quad \text{Mass (g)} \\
0 & \quad 0 & \quad 50 \\
1 & \quad 5730 & \quad 25 \\
2 & \quad 11460 & \quad 12.5 \\
3 & \quad 17190 & \quad 6.25
\end{align*}
\]

6.25 g of carbon-14 would remain after 17,190 years.