Radioactive half-life

Radioactive decay is a random process and we cannot predict which radioactive nuclei in a sample will decay at any given moment. However, the rate of radioactive decay follows a pattern. As a radioactive sample decays, less and less of the original substance is left and the radioactivity drops. The half-life of a radioactive material is the time taken for half of the radioactive nuclei in a sample to decay. This is also equivalent to the time taken for the radioactivity to drop to half of what it was.

When the radioactivity reaches one-half of its original level, one half-life has passed. When it reaches one-quarter of its original level, two half-lives have passed and the pattern continues. A graph of radioactive decay against time gives a characteristic shape called an exponential decay curve.

Table 2.3: Half-lives of important medical radionuclides

<table>
<thead>
<tr>
<th>Radionuclide</th>
<th>Half-life</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bismuth-213</td>
<td>46 minutes</td>
</tr>
<tr>
<td>Technetium-99m</td>
<td>6 hours</td>
</tr>
<tr>
<td>Lutetium-177</td>
<td>6.7 days</td>
</tr>
<tr>
<td>Iodine-131</td>
<td>8 days</td>
</tr>
<tr>
<td>Chromium-51</td>
<td>28 days</td>
</tr>
<tr>
<td>Strontium-89</td>
<td>50 days</td>
</tr>
</tbody>
</table>

Fig 2.33 A radioactive decay curve for strontium-90, which has a half-life of 28.8 years.

A tasty way to model radioactive decay

The aim of this activity is to illustrate the idea of exponential decay and half-life. You can use M&M’s to represent the nuclei of atoms.

What you need: pack of M&M’s, A4 plain paper, disposable plastic cup

1. Copy out the table to record your results.
2. Count the total number of M&M’s that you have, record this number in the table, and place them into the plastic cup.
3. Shake the cup and tip all the M&M’s on to the paper.
4. Those that have the ‘M’ facing upwards represent atoms that have decayed. Move these to one side to form a ‘discard’ pile.
5. Count the remaining ‘nuclei’ and record in your table.
6. Place these remaining nuclei back into the cup, shake them and tip out again.
7. Remove the decayed nuclei to the discard pile and count those remaining.
8. Continue until you have three or fewer nuclei.
9. Repeat the whole process two more times.
10. Draw a set of axes with the number of atoms remaining (vertical axis) and the number of shakes (horizontal axis). Using just this set of axes, plot points and draw a line of best fit through the points for each of the three trials.

- In this activity, the atomic nuclei were represented by M&M’s. What represented the half-life of the decay process?
- Are the shapes of the three curves similar or different? Comment on your answer.
- Do you think the overall shape of the curves would be different if you started with more atomic nuclei? Explain your answer.
- In this activity, could you predict when each individual nucleus would decay? Why is this similar to the behaviour of real radioactive atoms?

- In this experiment you would eventually end up with no ‘undecayed’ M&M’s. Would this be the case with a real radionuclide? Explain your answer.