Rutherford, radioactive atoms and mathematics

Ernest Rutherford showed that some atoms did decay into other types of atoms. He measured how long it took to decay and developed the term half life i.e. the time it takes for half of the radioactive sample to decay. The diagram below shows that when uranium (U) 235 decays, lead (Pb) 207 is formed.

![Diagram showing half life of uranium and lead]

**Question 1** Complete the following table for U-235

<table>
<thead>
<tr>
<th>Half life number</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Millions of years</td>
<td>713</td>
<td>2139</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Amount of U-235 left</td>
<td>One half</td>
<td>One quarter</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Question 2** Complete the table showing fractions, percentages and decimals

<table>
<thead>
<tr>
<th>Amount of U-235 left</th>
<th>One half</th>
<th>One eighth</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Fraction</td>
<td>1/4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Percentage</td>
<td>50%</td>
<td>6.25%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Decimal</td>
<td></td>
<td>0.125</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Question 3** Complete the following table for U-238 and Pb-207

<table>
<thead>
<tr>
<th>Half life number</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amount of U-235 in sample</td>
<td>0.5</td>
<td>0.125</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Amount of Pb-207 in sample</td>
<td>0.5</td>
<td>0.75</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Question 4  Numbers of atoms
If a radioactive sample of 4000 atoms has a half life of 100 years how many atoms will be left after
a) 100 years
b) 200 years
c) 300 years
d) 400 years
e) 500 years

Question 5  Extension questions
a) At the start there were 6000 atoms. Four hours later there are 1500 atoms left. What is the half life?
b) If half of a radioactive sample of atoms is left after 3 hours, what fraction will be left after 9 hours?
c) The half life of a sample of radioactive atoms has a half life of 5 days. If 200 atoms are left after 20 days, how many atoms were there to begin with?
d) If 75% of a sample of radioactivity has decayed in 12 minutes, what is the half life?

Finally, a slightly random cartoon to figure out:
Answers for Rutherford, radioactive atoms and mathematics

Question 1  Complete the following table for U-235

<table>
<thead>
<tr>
<th>Half life number</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Millions of years</td>
<td>713</td>
<td>1426</td>
<td>2139</td>
<td>2852</td>
</tr>
<tr>
<td>Amount of U-235 left</td>
<td>One half</td>
<td>One quarter</td>
<td>One eighth</td>
<td>One sixteenth</td>
</tr>
</tbody>
</table>

Question 2  Complete the table showing fractions, percentages and decimals

<table>
<thead>
<tr>
<th>Amount of U-235 left</th>
<th>One half</th>
<th>One quarter</th>
<th>One eighth</th>
<th>One sixteenth</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fraction</td>
<td>1/2</td>
<td>1/4</td>
<td>1/8</td>
<td>1/16</td>
</tr>
<tr>
<td>Percentage</td>
<td>50%</td>
<td>25%</td>
<td>12.5%</td>
<td>6.25%</td>
</tr>
<tr>
<td>Decimal</td>
<td>0.5</td>
<td>0.25</td>
<td>0.125</td>
<td>0.0625</td>
</tr>
</tbody>
</table>

Question 3  Complete the following table for Pb-207

<table>
<thead>
<tr>
<th>Half life number</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amount of U-235 in sample</td>
<td>0.5</td>
<td>0.25</td>
<td>0.125</td>
<td>0.0625</td>
</tr>
<tr>
<td>Amount of Pb-207 in sample</td>
<td>0.5</td>
<td>0.75</td>
<td>0.875</td>
<td>0.9375</td>
</tr>
</tbody>
</table>

Question 4  Numbers of atoms

If a radioactive sample of 4000 atoms has a half life of 100 years how many atoms will be left after

- a) 100 years 2000
- b) 200 years 1000
- c) 300 years 500
- d) 400 years 250
- e) 500 years 125

Question 5  Extension questions

- a) At the start there were 6000 atoms. Four hours later there are 1500 atoms left. What is the half life? 2 hours
- b) If half of a radioactive sample of atoms is left after 3 hours, what fraction will be left after 9 hours? 1/8
- c) The half life of a sample of radioactive atoms has a half life of 5 days. If 200 atoms are left after 20 days, how many atoms were there to begin with? 3200
- d) If 75% of a sample of radioactivity has decayed in 12 minutes, what is the half life? 6 minutes