The Timeline of **Radioactive Decay** for Uranium$^{238}$ ($U^{238}$)
About This Factfile

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First edition 2006
Second edition 2008
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Cover images (clockwise from top left)
- Uranium
- Thorium
- Bismuth
- Lead

Enquiries to

policy@theiet.org
Summary

This Factsheet shows the radioactive decay chain of uranium\(^{238}\), the resulting products, the radiation emitted in the process and the timescales involved.

**Uranium\(^{238}\) (U\(^{238}\)) Radioactive Decay**

<table>
<thead>
<tr>
<th>Type of Radiation(^{(2)}) ((\alpha, \beta, \gamma))</th>
<th>Nuclide</th>
<th>Half-Life</th>
</tr>
</thead>
<tbody>
<tr>
<td>(\alpha \gamma)</td>
<td>Uranium(^{238}) ((3))</td>
<td>4.47 billion years (^{(1)})</td>
</tr>
<tr>
<td>(\beta \gamma)</td>
<td>Thorium(^{234})</td>
<td>24.1 days</td>
</tr>
<tr>
<td>(\beta \gamma)</td>
<td>Protactinium(^{234m})</td>
<td>1.17 minutes</td>
</tr>
<tr>
<td>(\alpha \gamma)</td>
<td>Uranium(^{234})</td>
<td>245000 years</td>
</tr>
<tr>
<td>(\alpha \gamma)</td>
<td>Thorium(^{230})</td>
<td>80000 years</td>
</tr>
<tr>
<td>(\alpha \gamma)</td>
<td>Radium(^{226})</td>
<td>1600 years</td>
</tr>
<tr>
<td>(\alpha \gamma)</td>
<td>Radon(^{222})</td>
<td>3.823 days</td>
</tr>
<tr>
<td>(\alpha)</td>
<td>Polonium(^{218})</td>
<td>3.05 minutes</td>
</tr>
<tr>
<td>(\alpha \beta)</td>
<td>Lead(^{214})</td>
<td>26.8 minutes</td>
</tr>
<tr>
<td>(\beta \gamma)</td>
<td>Bismuth(^{214})</td>
<td>19.7 minutes</td>
</tr>
<tr>
<td>(\alpha \beta \gamma)</td>
<td>Polonium(^{214})</td>
<td>0.000164 seconds</td>
</tr>
<tr>
<td>(\alpha)</td>
<td>Lead(^{210})</td>
<td>22.3 years</td>
</tr>
<tr>
<td>(\beta \gamma)</td>
<td>Bismuth(^{210})</td>
<td>5.01 days</td>
</tr>
<tr>
<td>(\alpha \beta)</td>
<td>Polonium(^{210})</td>
<td>138.4 days</td>
</tr>
<tr>
<td>(\alpha \gamma)</td>
<td>Lead(^{206})</td>
<td>stable</td>
</tr>
</tbody>
</table>

\(\alpha\) – Alpha Radiation  
\(\beta\) – Beta Radiation  
\(\gamma\) – Gamma Radiation

\(^{(1)}\) The half-life of Uranium\(^{238}\) is 4.47 billion years.
\(^{(2)}\) The type of radiation emitted in each decay stage is indicated by the symbols: \(\alpha\) for alpha radiation, \(\beta\) for beta radiation, and \(\gamma\) for gamma radiation.
Notes

1. The half-life of Uranium\(^{238}\) is 4.47 billion years. Given that the estimated age of the Earth is also about 4.5 billion years, in this time period, about half of the Uranium present when the Earth was formed has decayed and about half still exists today.

2. Radioactivity is the emission of particles or electromagnetic energy from the nucleus of an atom. The three types of radioactive decay are alpha (\(\alpha\)), beta (\(\beta\)) and gamma (\(\gamma\)).

   Alpha particles are helium nuclei each made up of two protons and two neutrons.

   Taking the example:

   \[
   ^{238}\text{Uranium} \rightarrow ^{234}\text{Thorium} + 4\text{Helium}
   \]

   the daughter nucleide, Thorium has two fewer protons and two fewer neutrons than the parent nucleide.

   Beta particles are electrons, the mass of which are negligible on the atomic weight scale. In beta emissions, the parent and daughter elements have virtually the same atomic weights.

   Gamma rays are very high frequency electromagnetic radiation emitted in many radioactive changes irrespective of whether alpha or beta particles are emitted.

3. Uranium\(^{238}\) is also fertile in that it can capture a neutron transforming, following radioactive decay, into Plutonium which is fissile and can be used as fuel in a nuclear reactor.

   \[
   ^{238}\text{Uranium} \rightarrow ^{239}\text{Uranium} \rightarrow ^{239}\text{Neptunium} \rightarrow ^{239}\text{Plutonium}
   \]

Further Information

- IET Energy related factfiles
  http://www.theiet.org/factfiles/energy/

- IET nuclear factfile series
  - The principles of nuclear power
    http://www.theiet.org/factfiles/energy/nuc-prin-page.cfm
  - Nuclear reactor types
    http://www.theiet.org/factfiles/energy/nuc-reac-page.cfm
  - Nuclear safety
  - Legal framework of nuclear power in the UK
  - Nuclear decommissioning
    http://www.theiet.org/factfiles/energy/nuc-dec-page.cfm
  - Nuclear waste disposal and transport of spent fuel
    http://www.theiet.org/factfiles/energy/nuc-waste-page.cfm
  - The nuclear fuel cycle
    http://www.theiet.org/factfiles/energy/nuc-fuel-page.cfm
  - The radioactive decay of uranium\(^{238}\)
    http://www.theiet.org/factfiles/energy/uranium238-page.cfm
  - Glossary of nuclear terms
    http://www.theiet.org/factfiles/energy/nuc-terms-page.cfm

Further Reading
