**Nuclear Power**

**Activity 3: Investigating Plutonium Production**

Plutonium (Pu) is a transuranic element that does not occur naturally on Earth because of its short half-life (~24,000 years). It is, however, produced in commercial nuclear reactors as well as weapons production reactors. Because it is fissile, i.e. undergoes neutron-induced fission, Pu is important as a fuel for electricity generation and as a component of nuclear weapons. This activity explores how Pu is produced, the concept of nuclear reactions and the nuclide chart. A portion of the nuclide chart showing some of the heavier elements is shown below. Use it to complete this activity.

heavy elements.tif

1. 239Pu is produced in a nuclear reactor when the nucleus of a 238U (a fertile element) atom captures a slow (thermal) neutron. On the portion of the nuclide chart below, trace the path of this nuclear transformation. Identify each type of reaction associated with each step.

NCdec_Pu-production.gif

1. Write the nuclear reaction(s) describing the production of 239Pufrom 238U.



1. Most of the time (62-73 %) when a 239Pu nucleus captures a neutron, it undergoes neutron-induced fission. The nuclear reaction below describes one possible fission outcome. What is the other fission product of this reaction?



1. Use the interactive Nuclide Chart (<http://www-nds.iaea.org/relnsd/vchart/index.html>) to determine the stable products of both fission products in the reaction above. What are the types and numbers of decays involved in these two decay series?



1. A small percentage of the time when 239Pu captures a neutron it is transmuted to a different heavier Pu isotope. Write out the nuclear reactions necessary to produce, 242Pu.



1. With this reaction in mind complete the graph below, by schematically drawing curves for the 239Pu, 240Pu, 241Pu and 242Pu.

Pu evolution.tif

1. What does this graph tell you about the relation between the time fuel spends in the reactor and the isotopic composition of plutonium when it is removed.
   1. How long do you think fuel spends in a plutonium production reactor to make weapons grade plutonium (>93 % 239Pu)?

**Short time, i.e. only days or weeks**

* 1. Why isn’t reactor fuel which typically spends 54 months in the reactor core not good for weapons production?

**Its 239Pu content is too low and its other plutonium isotopes are too abundant**