uranium - the Key Element

There are 92 naturally occurring elements but only one, uranium, has become the key to the operation of the nuclear fuel cycle. This singular use of uranium stems from its unstable, radioactive atomic structure. The safety problems arising from the use of uranium as an energy source stem from this highly radioactive property of uranium and the wastes it produces.

THE URANIUM ATOM

An atom can be pictured as a small universe with a nucleus at its centre and electrons orbiting around it. The nucleus contains protons and neutrons. Each electron has a negative charge and each proton a positive charge; since there are an equal number of protons and electrons the atom is neutral.

Atoms of the same element have the same number of protons (the atomic number). However, the same element can have atoms with varying numbers of neutrons in their nucleus giving atomic species of different atomic weights known as nuclides. Thus for the key element uranium, the nucleus of uranium-235 has 143 neutrons and 92 protons and uranium-238 has 146 neutrons and 92 protons.

RADIOACTIVITY OF THE WASTES

Some **nuclides** are unstable and decay spontaneously into other nuclides. Unstable nuclides are called **radionuclides** and their decay is called **radioactivity.**

The half-life of uranium-235 is 713,000,000 years

The half life for uranium-238 is 4500,000,000 years.

Some radionuclides are more unstable than others and decay at a faster rate. Each radionuclide decays at its own characteristic rate. This is known as its **half-life**. One half-life is the time taken for half the atoms in a quantity of a radionuclide to decay.

The unit of radioactivity is a **becquerel** which is 1 disintegration each second. A **terebecquerel** is 1012 disintegrations a second.

IONISING RADIATIONS

As radioactive atoms decay, alpha, beta and gamma rays are emitted.

Alpha rays are heavy positively charged particles travelling at high speed (several kilometers a second). These rays emanate from heavy elements such as uranium, plutonium and americium.

Beta rays are negatively charged electrons seven thousand times lighter than alpha particles.

Gamma rays are electromagnetic radiation which emanates from most though not all radionuclides.

ATOMIC FISSION

Because radioactive decay of uranium atoms is over a great length of time the energy released cannot be readily harnessed.

The energy in atomic nuclei is only unleashed through a more drastic rupture of the atom. This became practical when it was discovered in 1938 that when uranium-235 is bombarded by neutrons it is unstable enough to split or fission into two small atoms at the same time releasing more neutrons.

CHAIN REACTION

As uranium-235 atoms split more and more neutrons are released until a chain reaction starts. Some fission products and their half-life are:

RADIONUCLIDE	HALF-LIFE
Radon-222	4 days
Iodine-131	8 days
Krypton-85	10 years
Tritium (Hydrogen-3)	12 years
Strontium-90	29 years
Cesium-137	30 years
Americium-241	433 years
Radium-226	1,622 years
Plutonium-239	24,000 years

CONTROLLED & UNCONTROLLED CHAIN REACTIONS

An atomic explosion is an uncontrolled chain reaction.

In a nuclear reactor the chain reaction is controlled by using rods containing boron, an element with the capacity to 'mop up' excess neutrons. The safe operation of a reactor depends on keeping the number of neutrons being released evenly balanced with the number absorbed by uranium-235 atoms in the splitting process.

When the number of neutrons around the uranium fuel gets out of control then an accident such as those at Windscale, Three Mile Island, Chernobyl will occur.

PLUTONIUM

Uranium-238, unlike uranium-235, rarely fissions. But a uranium-238 atom can capture a neutron to produce a plutonium-239 atom.

Plutonium-239 fissions faster than uranium-235 but still at a rate suitable to use in nuclear explosions. Plutonium thought to be useful fuel for breeder reactors specially designed to generate more plutonium-239 than it 'burns'. So far it has not functioned successfully in practice.

Plutonium is being mixed with uranium (MOX - mixed oxide fuel) for use in thermal reactors.

Information sources:

★ Information from the Movement Against Uranium Mining (MAUM) public education sheet 'Uranium : The Key Element.' used with permission from the Sustainable Energy and Anti-Uranium Service Inc. SEA-US: www.sea-us.org.au