5.15 Radionuclide Identification

High Purity Germanium (HPGe) is a semiconductor with a bandgap of $E_g = 0.66$ eV.[20] At low temperatures, the density of electrons in the conduction band (and the density of holes in the valence band) in Ge is low enough that it is essentially an insulator. A high voltage across a crystal of germanium will generate an electric field in that crystal, but no current will flow.

If the crystal is then struck by a photon with sufficient energy to promote an electron from the valence band to the conduction band, the result will be an electron-hole pair. The hole and the electron will be swept in opposite directions by the electric field, and will register as a current pulse when they reach the electrodes creating the high voltage. If all of the photon energy is deposited in the crystal, then the number of electron-hole pairs generated by the incoming photon depends on the photon energy:

$$N = \frac{E_\gamma}{E_g}$$

So it is possible to use the magnitude of these pulses to measure the energy of the incident photons.

Warning!

The HPGe detector detects radiation by observing the small current spikes of electron-hole pairs created in the Ge crystal by the incident radiation. There is a high voltage across the crystal, which is normally non-conducting. If the crystal reaches a 'high' temperature, the thermal energy generates electron-hole pairs which make the crystal conductive, the high voltage creates a high current (briefly) in the crystal, and we have to buy a very expensive new detector. Make *absolutely sure* that there has been liquid nitrogen in the detector dewar for at least six hours before you turn on the high voltage.

Procedure

1. Use the known sources and the chart of the nuclides (or other reference source) to make a plot of energy *vs* MCA channel number. From this plot, determine an appropriate calibration equation for converting channel number to energy.

2. Find the γ energy(ies) of the unknown sources, and use these energies to identify the unknowns. Bear in mind that many radioactive sources

decay via a long chain of reactions, each with a characteristic half-life. Depending on the age of the sample relative to its half-life, you may find that there are numerous daughter isotopes in the sample, which can complicate your analysis.