X-ray analysis with a NaI Detector and Multi-Channel Analyser (MCA)

X-ray can be produced in naturally occurring nuclear transitions eg. Cs-137 beta decay which produces a prominent 662 KeV gamma ray, but also a 32.3 KeV X-ray.

The Cs-137 beta decay is shown below. 93.5% of the time Cs-137 decays to Ba-137* (*=excitedThe excited Ba-137* then decays to the Ba-137 ground state emitting a 662 KeV gamma. Only 6.5% of the time Cs-137 decays to the Ba-137 ground state.

$${}_{55}Cs^{137} \text{ -> } {}_{56}Ba^{137(*)} + {}_{-1}e^{0} + {}_{0}v^{0}$$

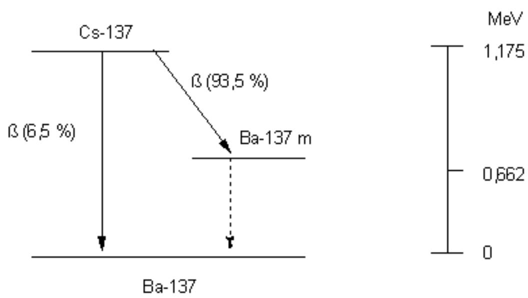

Fig. 1 Decay scheme of Cesium-137 according to LEDERER et al (1967)

But some fraction of the time the gamma ray does not escape the atom, but ejects an inner core electron, eg. K electron. The K electron leaves the atom with the gamma ray energy minus the K binding energy. The process is called **internal conversion**. A K x-ray is produced when the K shell is filled from the L,M levels. For barium, Z=56, the x-ray is at 32.3KeV.

If heavy metals as Pb(Z=82), W(Z=74), or Au(Z=79) are placed near the Cs-137 source a similar K electron ejection can take place and Pb, W, Au, x-rays can be observed.

Procedure

1) Turn on the NaI detector and associated electronics. Allow 10 minutes to stabilize.
2) Place the Cs-137 source on the NaI and take a spectrum. Use the barium 32KeV x-ray and cesium 184 KeV backscatter gamma to calibrate the NaI detector.
3) Place the C2-137 source near the Pb, W, Cu and record spectra remembering to **clear** and **start**. Record the energy of the x-ray given by the MCA. Check that the 662 Mev gamma line has not shifted each time.
4) Fill in the table with your measurements, the %difference w.r.t.the accepted value, and Moseley's Law.

Metal	Kα measured	Channel #	Kα accepted	% difference	$E_{K\alpha}$ =(Z-1)^{2}x13.6(1-1/2^2) eV
Ba	32.3 KeV		32.3 KeV	0.0%	
Pb			67.0 KeV		
W			54.4 KeV		
Cu			?		

5) Comment on sources of error and agreement between experiment and Moseley's Law.