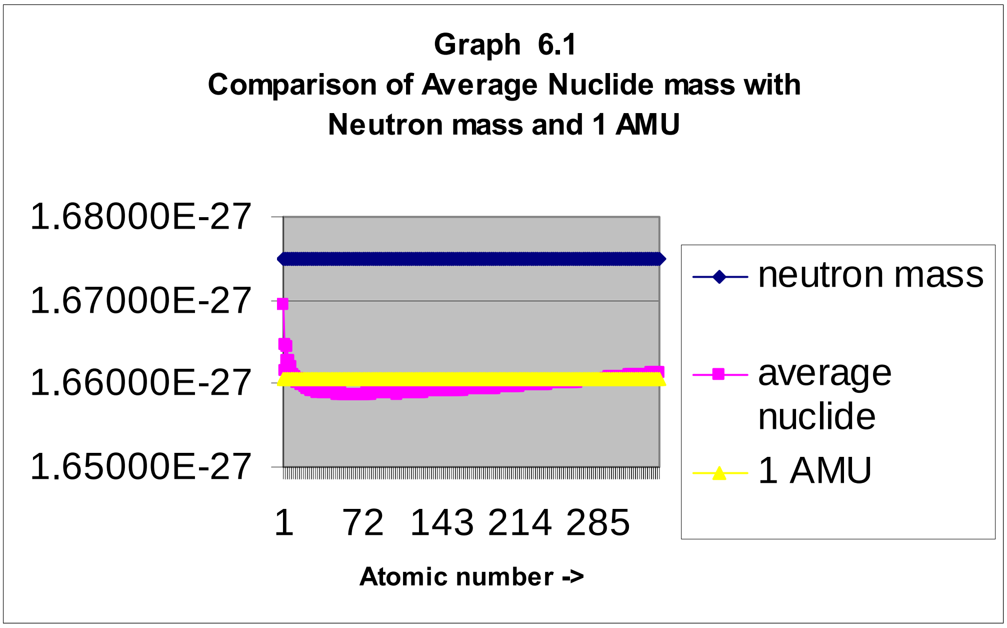
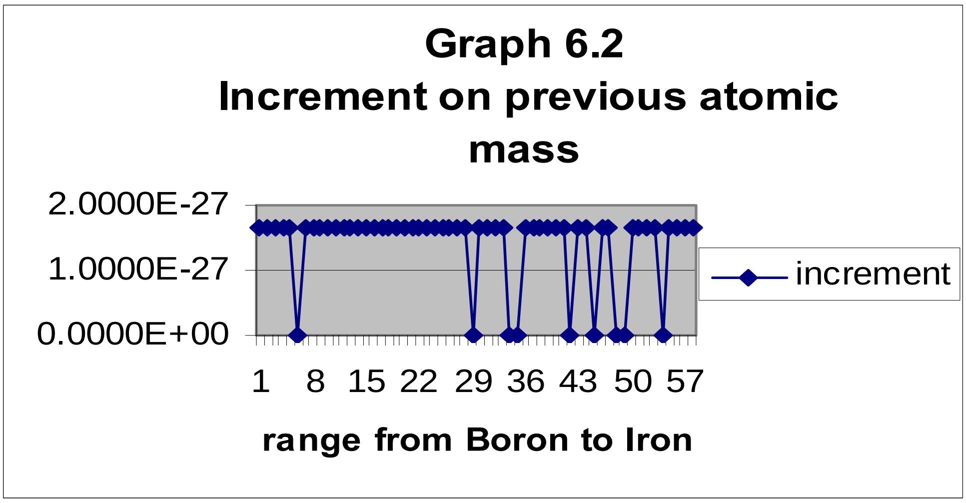
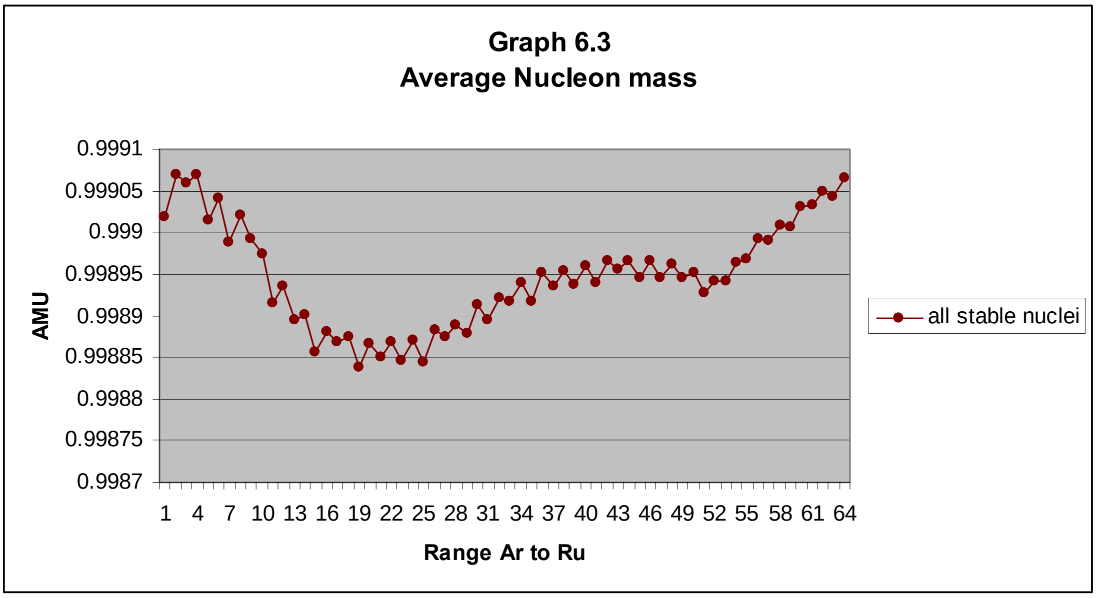
6.1. Taking the table of Atomic weights, including the natural isotopes, from Wikipedia, the atomic Number A is the total number of nucleons, and Z is the number of Protons (including the Electron mass), Then the average mass of a nucleon can be calculated. This shows that for all atoms and isotopes the average nucleon mass is significantly less that that of "a Neutron", as shown in Graph 6.1. [In the data tables this is referred to as the "nuclear excess mass" which is calculated as a variation on 1 AMU = 1/12 of the ^{12}C Carbon atom.]



The nuclear chemical data in Wikipedia is structured around the most populous mix of isotopes, and if these are plotted as mass increments on the preceding atomic number the series appears as graph 6.2.

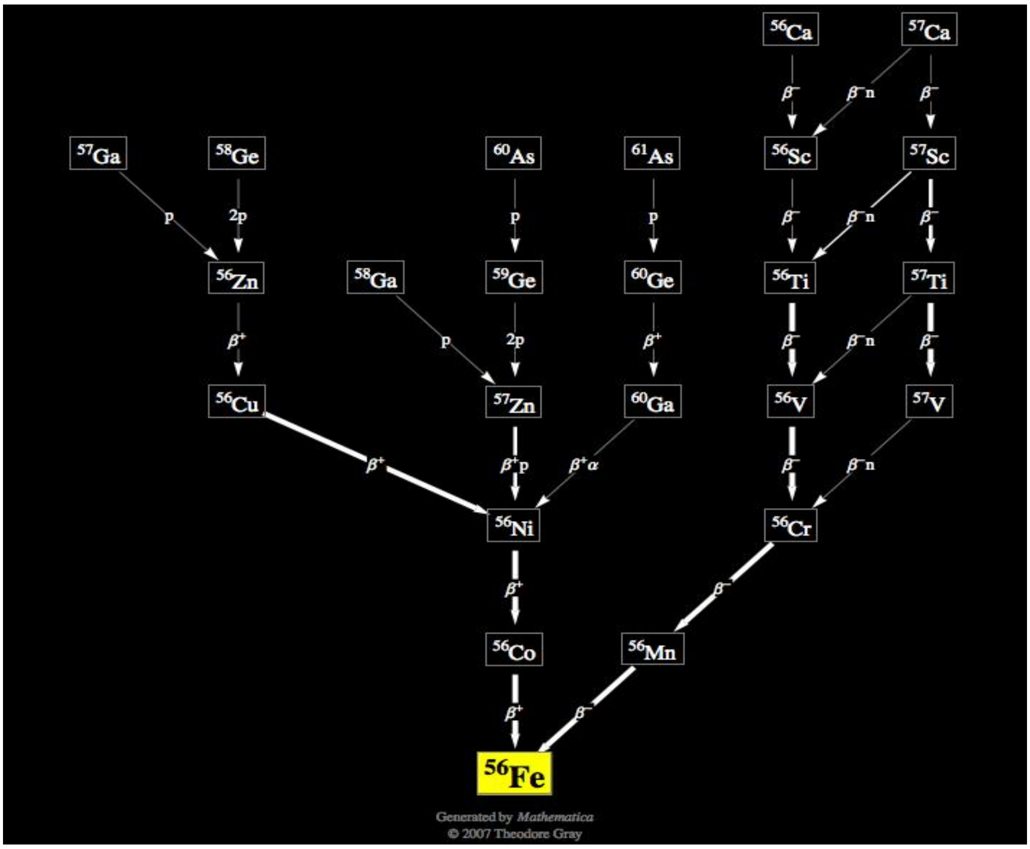


The interruptions in the linear trend arise from unstable Isotopes. If the unstable isotopes are removed, leaving only the stable atomic numbers, the curve is smoothed. However the trend is not a simple catenary as suggested in graph 6.1 If the range is constrained there is a trend as shown in graph 6.3, with the "Lightest" isotope in terms of average nucleon mass at 56Fe, and another minimum at 88Sr.



Below Ar the change in average mass is so great as to obscure the subtleties in graph 6.3, and beyond 88Sr the trend is close to linear, but still with the irregularities.It is clear that there is something else at work in terms of atomic number.

Isotopes are identified in the data as "versions" of the element number "Z", however Isotope decays do not take place in isolation; The "lowest point" in the curve of stability is ^{56}Fe and the decay chain leading to this is as fig 6.4:

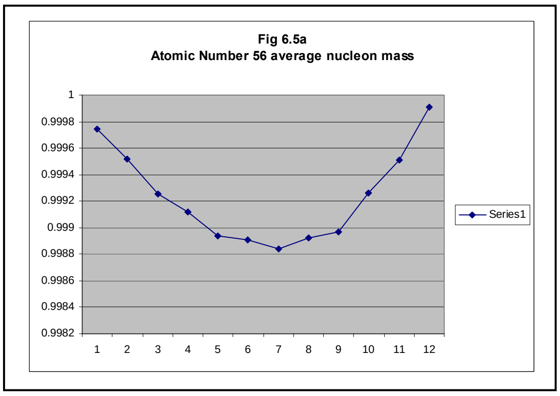


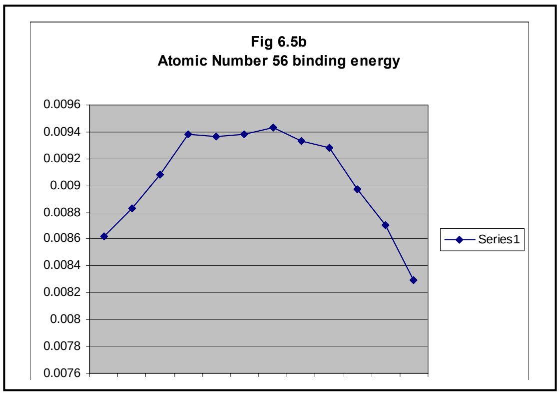
(Fig 6.4, data from www. Periodictable .com).

This shows that the primary path to stability is by a sequence of β decays: with the average nuclear mass, and binding energy for each isotope: Table 6.5.

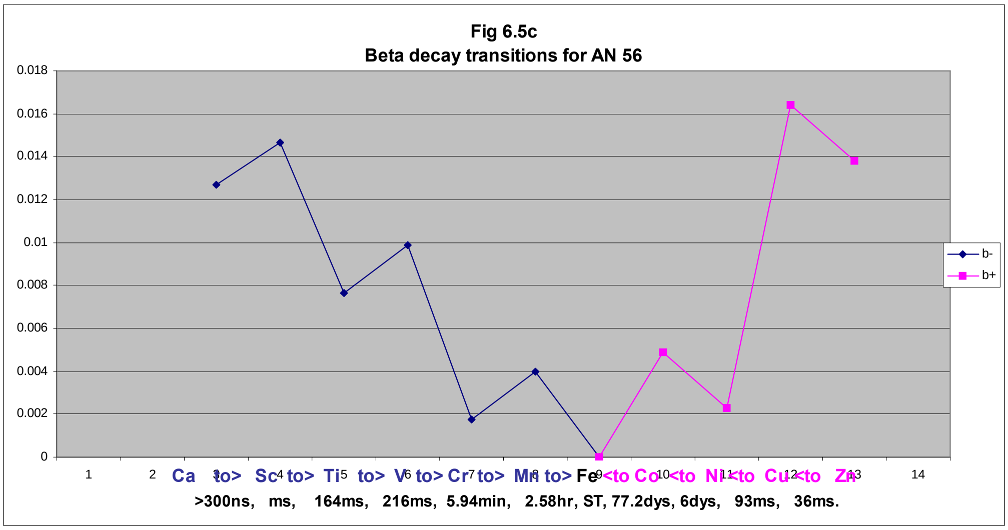
symbolA		Z	N	Mass (AMU)	Life	Mode	Average NM	Binding
^{56}Ca	56	20	36	55.98557	10# ms [>300 ns]	β–	0.99974	0.008623
^{56}Sc	56	21	35	55.97287	35(5) ms	β–	0.99952	0.008834
^{56}Ti	56	22	34	55.9582	164(24) ms	β–	0.99925	0.009081
^{56}V	56	23	33	55.95053	216(4) ms	β–	0.99912	0.009385
^{56}Cr	56	24	32	55.9406531	5.94(10) min	β–	0.99894	0.009365
^{56}Mn	56	25	31	55.9389049	2.5789(1) h	β–	0.99891	0.009381
56Fe	56	26	30	55.9349375	STABLE		0.99884	0.009437
^{56}Co	56	27	29	55.9398393	77.233(27) d	β+	0.99893	0.009334
^{56}Ni	56	28	28	55.942132	6.075(10) d	β+	0.99897	0.009278
^{56}Cu	56	29	27	55.95856	93(3) ms	β+	0.99926	0.008969
^{56}Zn	56	30	26	55.97238	36(10) ms	β+	0.99951	0.008709
^{56}Ga	56	31	25	55.99491		p to 55 Zn	0.99991	0.008291

Which can be represented graphically Fig 6.5a, and 6.5b:



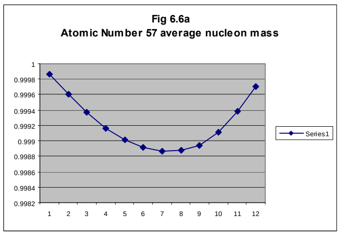


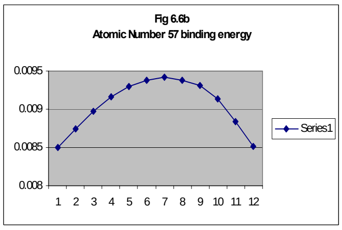
This can also be presented as the change in average mass per transition, and the associated half-life, fig 6.5c:

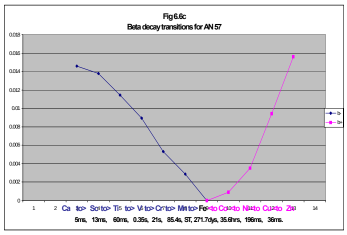


Note that an increase in Z number are β^- decays whilst a reduction in Z number are β^+
The transition from 56Ga is by Proton decay to 55Zn and thereafter by β+ to 55 Mn.

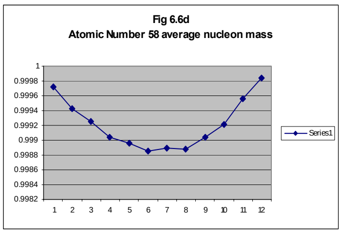
If this is repeated for 57Fe

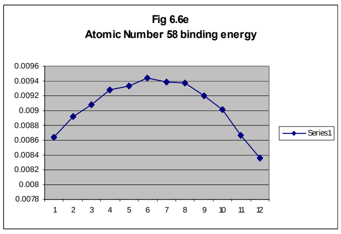


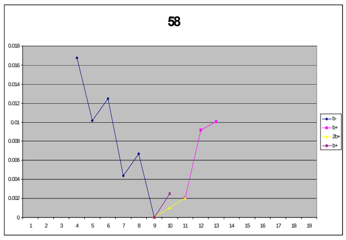




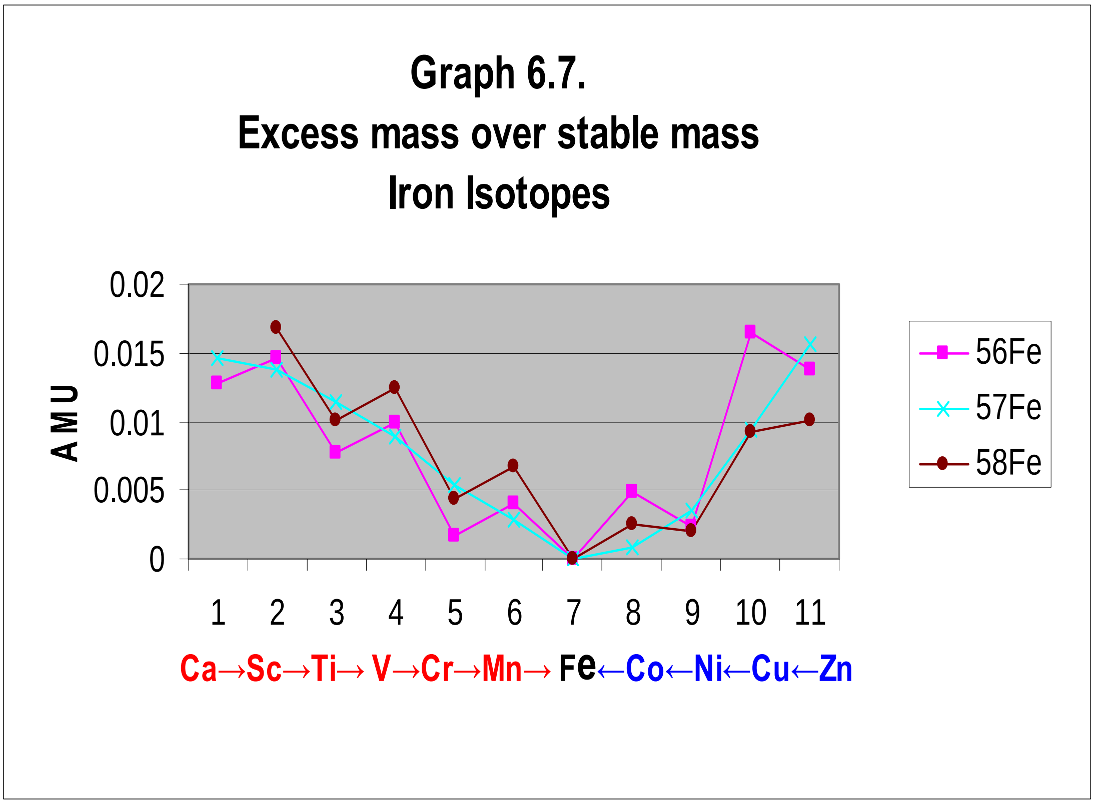
and 58 Fe:





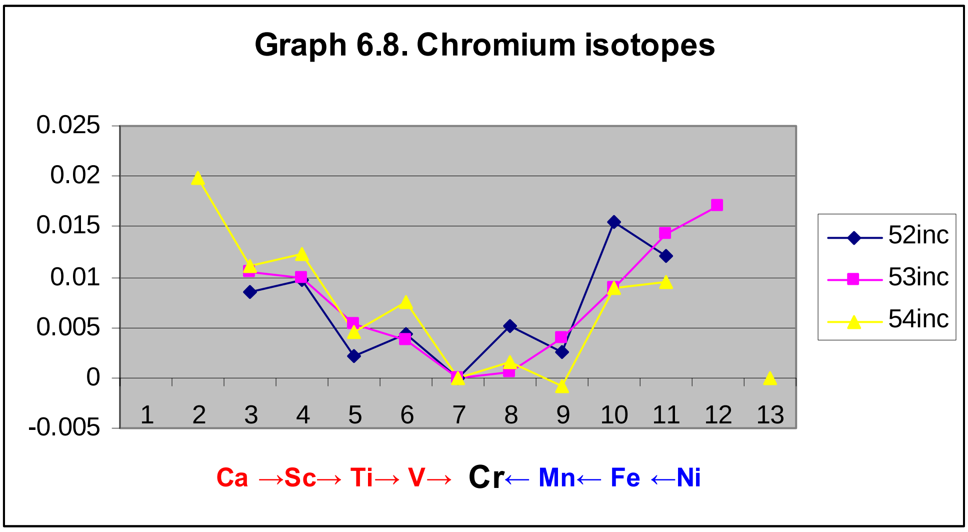


And if these are superimposed as Graph 6.7:

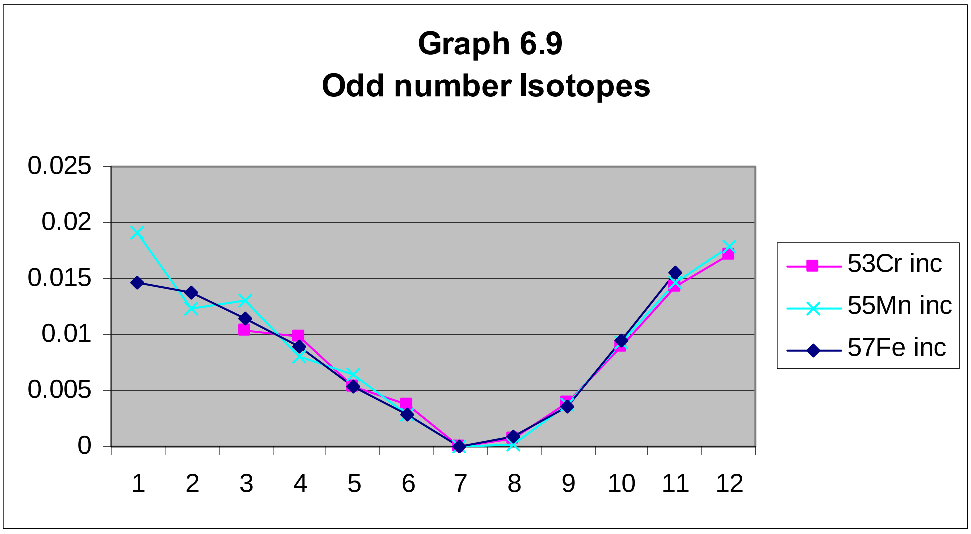


This shows three distinct trends converging on the stable isotope. and this pattern shows in other decay paths.

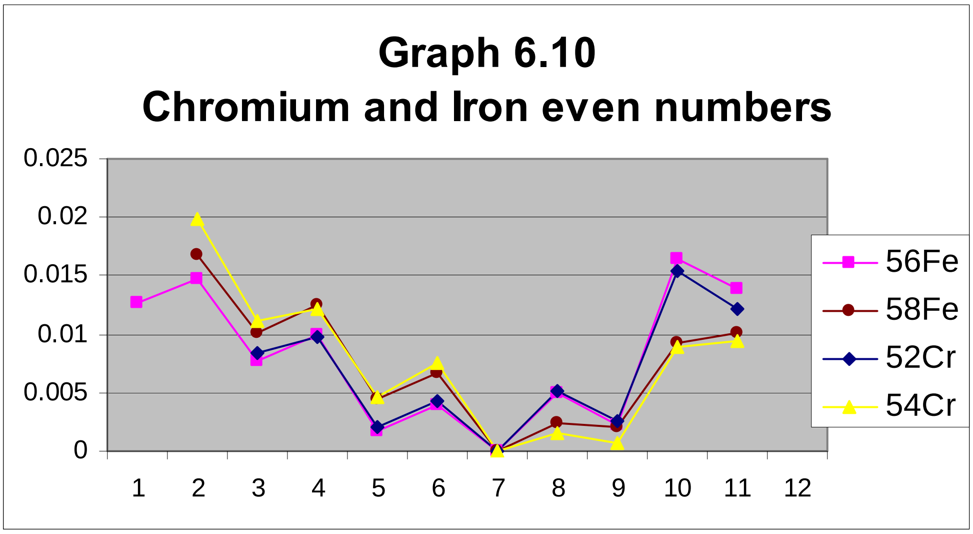
This pattern is also observed in Chromium which also has three stable isotopes as Graph 6.8:



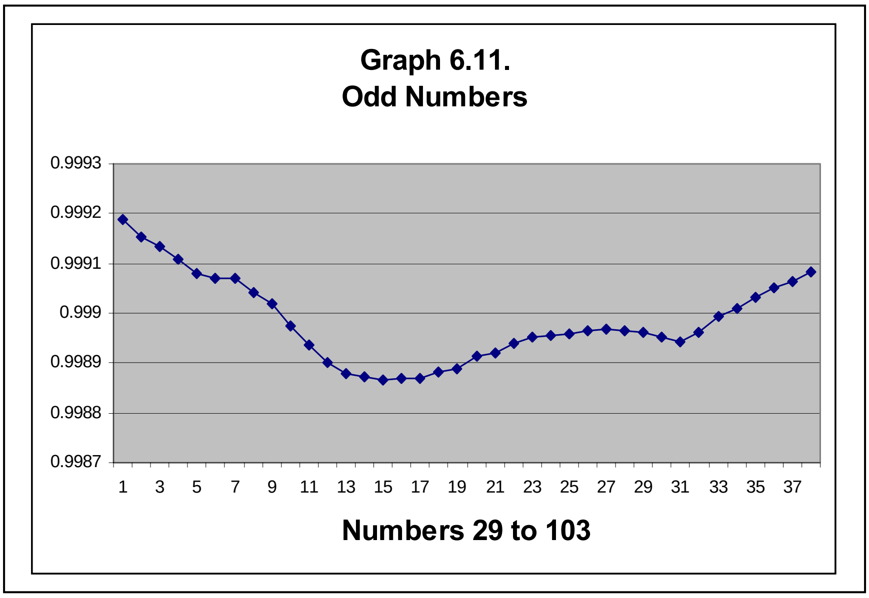
If these effects are combined, common patterns appear: for odd numbers of A,
For the samples 53Cr, 55Mn, and 57Fe the progression is a curve, and all these stable nuclei have fractional spins as in fig 6.9.



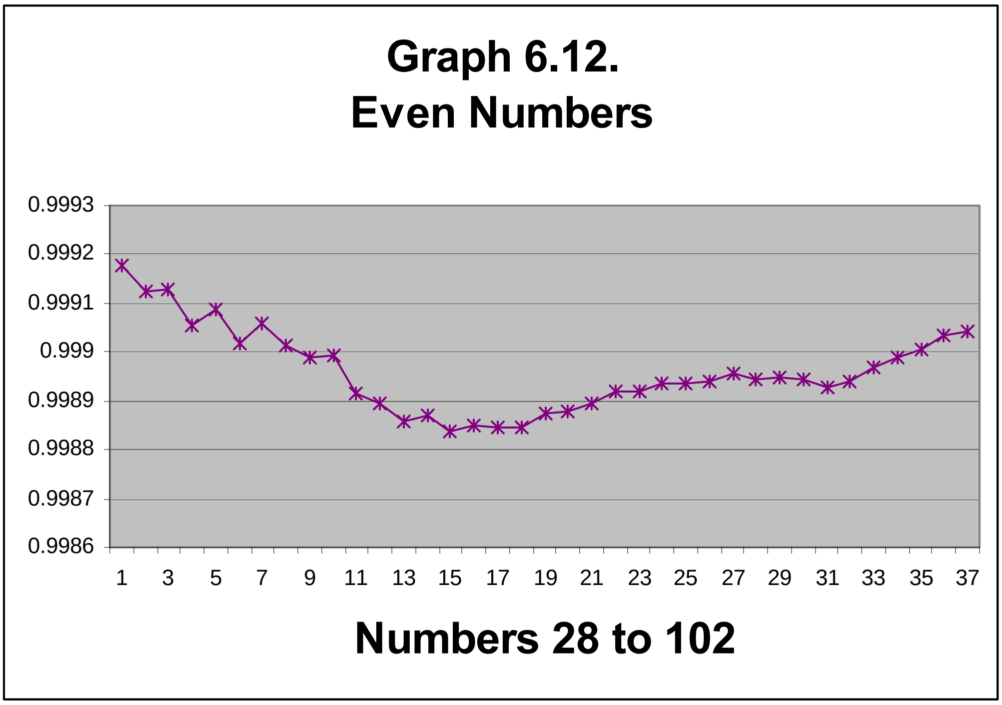
However for even Numbers of A there is a “saw tooth” pattern as Graph 6.10:



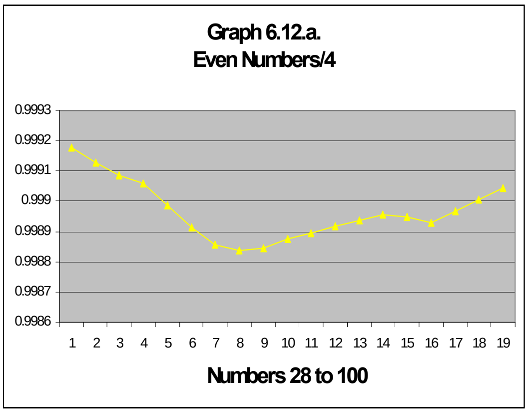
Note the common incremental values for 56Fe and 52Cr,
and a similar coincidence for 58Fe and 54Cr. If the trend is plotted for odd atomic numbers, a clear progression emerges, as Graph 6.11

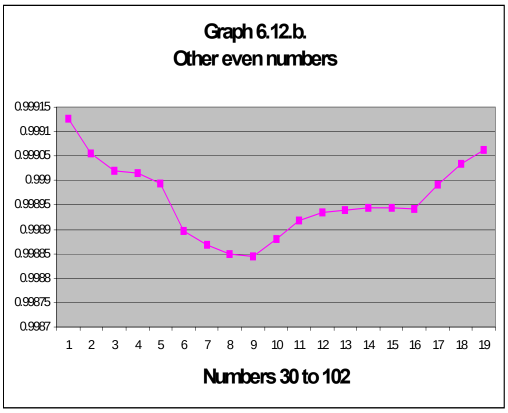


However for even numbers the graph is as 6.12:

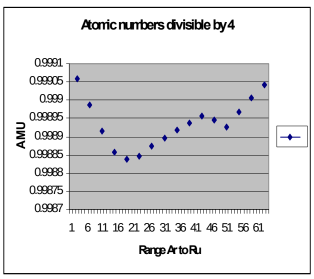


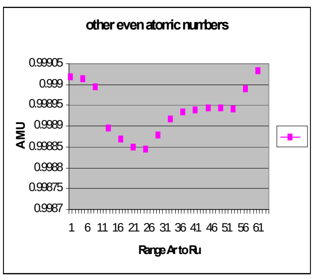
As suggested in Graph 6.10, the even numbers are divided into those divisible by 4, and other even numbers

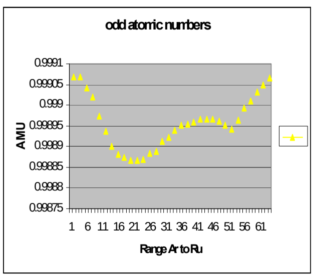




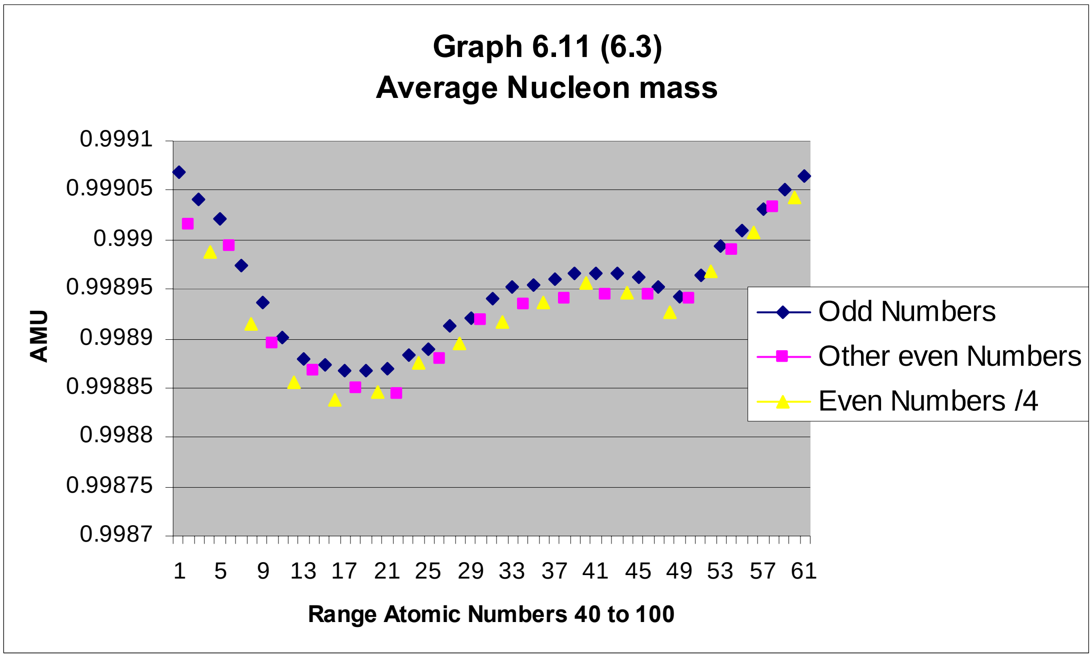
It would appear that there are three distinct classes of stable isotopes, and three distinct "curves of stability": those with odd numbers, which are characterised with fractional nuclear spins; and those with even nuclear numbers, with zero nuclear spin, in which the distinction appears to be between those which are divisible by four, and the other even numbers. If these are compared over the range chosen for Graph 6.3 the following results appear:







And in combination these duplicate the results of Graph 6.3:



6.6. This analysis has been carried out on all the 197 stable isotopes. All display the characteristic pattern of a sequence of β decays. All odd Atomic numbers exhibit the sequential curve of Fig 6.9, whilst all even Atomic numbers exhibit the "saw tooth" pattern of Fig 6.10. The significant finding is that there is no atomic number with more than one stable Z number. However there is another trend; at low atomic numbers there are more β– decays but at higher Atomic numbers there are more β+ decays.

6.7. The analysis of the Isotope data is not complete, but there are clear rules.

- There is only one fully stable "Z" isotope for a given atomic number "A" and there are only 197 of these.
- There are no stable isotopes above ^{208}Pb. For any given Atomic number, most decays are either β^-, resulting in an increase in the Z number, or β^+, (or ε), resulting in a decrease in the Z number both converging on the unique Z number for the stable A number.
- 2β– and 2β+ transitions are all from semi-stable isotopes with very long half-lives, and always to the fully stable isotope of that atomic number.
- All other decays are directly or indirectly to a point in another β chain.

http://www.chemicalforums.com/index.php?board=27.0