Nuclear Physics - Binding Energy

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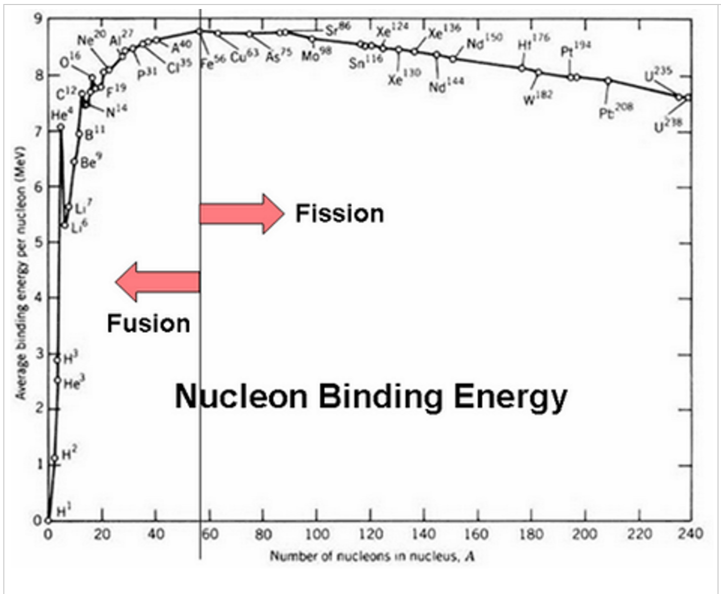
- The mass of a nucleus is less than the mass of its constituents
- We know that mass and energy are equivalent and that $E=mc^2$ applies to all energy changes
- The 'missing mass', or 'mass defect' when nucleons join is converted into energy and released.
- If you wanted to separate the nucleons - you need to supply the same amount of energy as was emitted when the constituents joined.

Binding energy is the energy needed to separate all the nucleons in an nucleus.

One atomic mass units, 1u = 1.661×10^{-27}Kg is approx 931.5MeV



Comparing the average binding energy per nucleon is useful. As you might guess the highest average BE per nucleon element/isotope needs the most energy to separate the nucleons.

The nuclei which require the most energy to tear them apart are the most stable. This suggest that the most stable nucleus is in fact Iron.

Note the 'fusion/fission' areas. Elements move towards the place of most stability - ie Iron.

Low mass nuclei fuse, and in the process mass is converted ot energy. High mass nuclei split - and again mass is lost (overall). In fission of course the nucleon number can go down too, meaning the average BE increases.

More energy is released per nucleon in fusion than fission

Example of Fusion

$^2H + {}^3H \rightarrow {}^4He$

He has 4 nucleons .... Average BE = 6.8 MeV
so BE = 4 × 6.8 = 27.2 MeV

BE of ^2H = 1 × 2 = 2 MeV   BE of ^3H = 3 × 2.6 = 7.8 MeV
= 2 + 7.8 = 9.8 MeV

So when a ^2H & a ^3H fuse : 27.2 − 9.8 = 17.4 MeV is released

Example of Fission

BE of $^{235}U = 235 \times 7.5 = 1739$ MeV

Split into ^{92}Rb & ^{140}Cs (Δ 3 p)

Rb: $\underbrace{92 \times 8.8}$ Cs: $\underbrace{140 \times 8.2}$

$+ = 1957.6$ MeV

So energy released $= 1957.6 - 1739$

$= 218.6$ MeV