Binding energy per nucleon

Another useful quantity is the **binding energy per nucleon.** It can be defined simply as:

Binding Energy per nucleon = Binding Energy/ Nucleon Number

The graph below (Figure 1) shows the binding energy per nucleon against nucleon number. Elements with a high binding energy per nucleon are very difficult to break up. Iron 56 is close to the peak of the curve and has one of the highest binding energies per nucleon of any isotope.

(N.B the determination of the value of binding energy per nucleon for a given nucleus is a complex process and depends on the precise way it is calculated. Nickel 62, with a binding energy per nucleon of 8.7948 MeV exceeds that for iron 56 (8.7906 MeV).

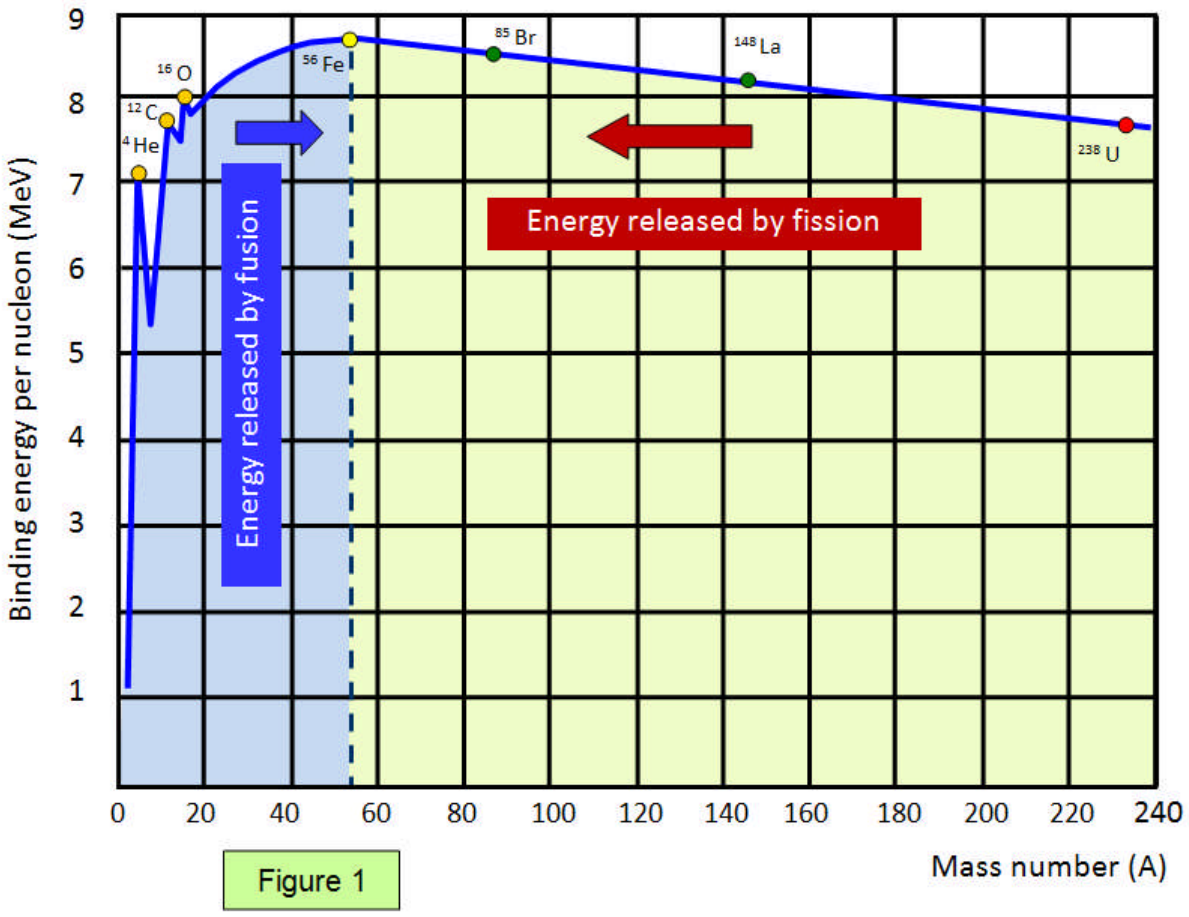

Figure 1

The part of the curve to the left shows that two light elements can produce energy by fusion while the part of the curve to the right shows that a heavy element can produce energy by fission. Notice that the diagram has been drawn with the binding energies per nucleon being shown as positive – this represents the energy needed to separate the particles.

Therefore if a reaction takes place where the products are closer to the base then the original nucleus

(nuclei) then energy is given out.

For helium the binding energy per nucleon is 28.3/4 = 7.1 MeV.

The helium nucleus has a high binding energy per nucleon and is more stable than some of the other nuclei close to it in the periodic table.

Some of the binding energies per nucleon for some common elements are shown in the following table.

Element	Mass of nucleons (u)	Nuclear mass (u)	Binding energy (MeV)	Binding energy per nucleon (MeV)
Deuterium	2.01594	2.01355	2.23	1.12
Helium 4	4.03188	4.00151	28.29	7.07
Lithium 7	7.05649	7.01336	40.15	5.74
Beryllium 9	9.07243	9.00999	58.13	6.46
Iron 56	56.44913	55.92069	492.24	8.79
Silver 107	107.86187	106.87934	915.23	8.55
Iodine 127	128.02684	126.87544	1072.53	8.45
Lead 206	207.67109	205.92952	1622.27	7.88
Polonium 210	211.70297	209.93683	1645.16	7.83
Uranium 235	236.90849	234.99351	1783.80	7.59
Uranium 238	239.93448	238.00037	1801.63	7.57

A very useful web site containing a huge nuclear database is to be found at Nuclear data

It may be more helpful to consider the binding energy per nucleon diagram in the form shown in Figure 2 where reactions tend to move the nuclei towards the valley at the bottom of the curve. (In this case note that the binding energies per nucleon are given as negative values).

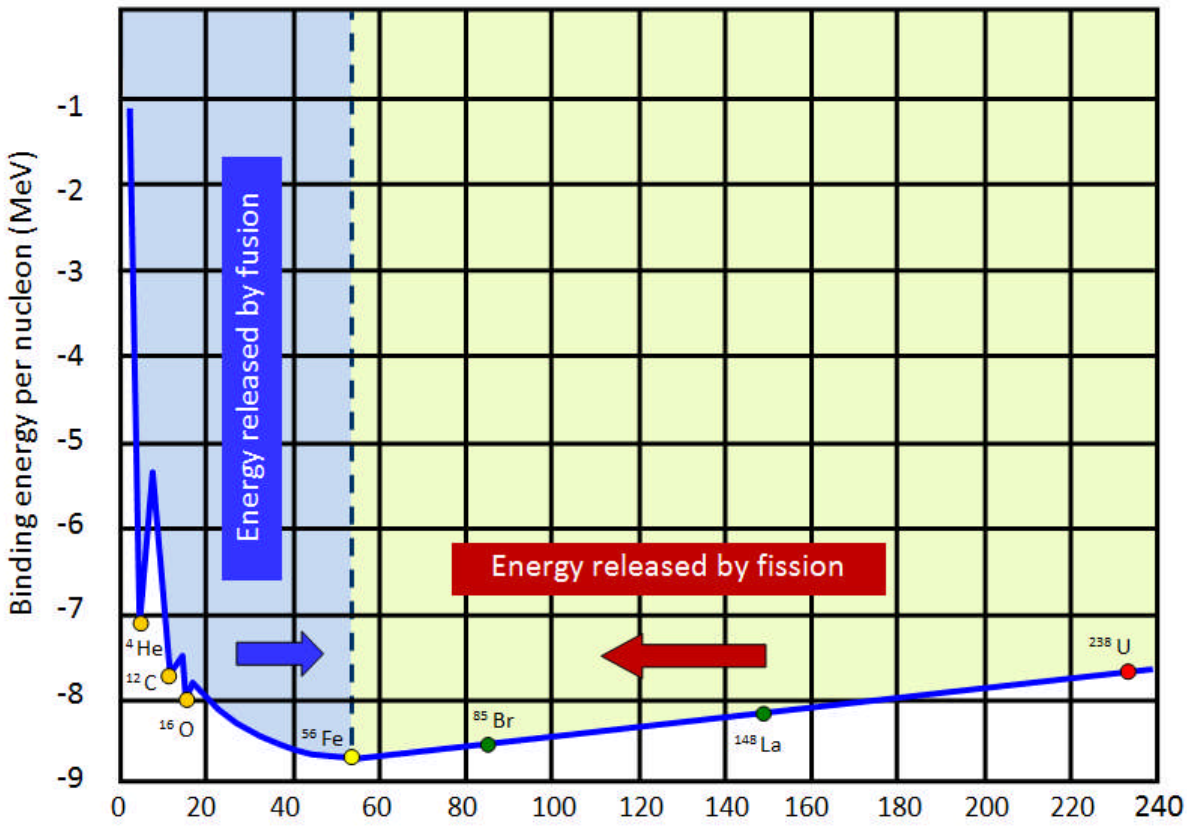
Binding energy per nucleon (MeV)
-1
-2
-3
-4
-5
-6
-7
-8
-9
Energy released by fusion
Energy released by fission
4 He
12 C
16 O
56 Fe
85 Br
148 La
238 U
0
20
40
60
80
100
120
140
160
180
200
220
240
Mass number (A)

Figure 2