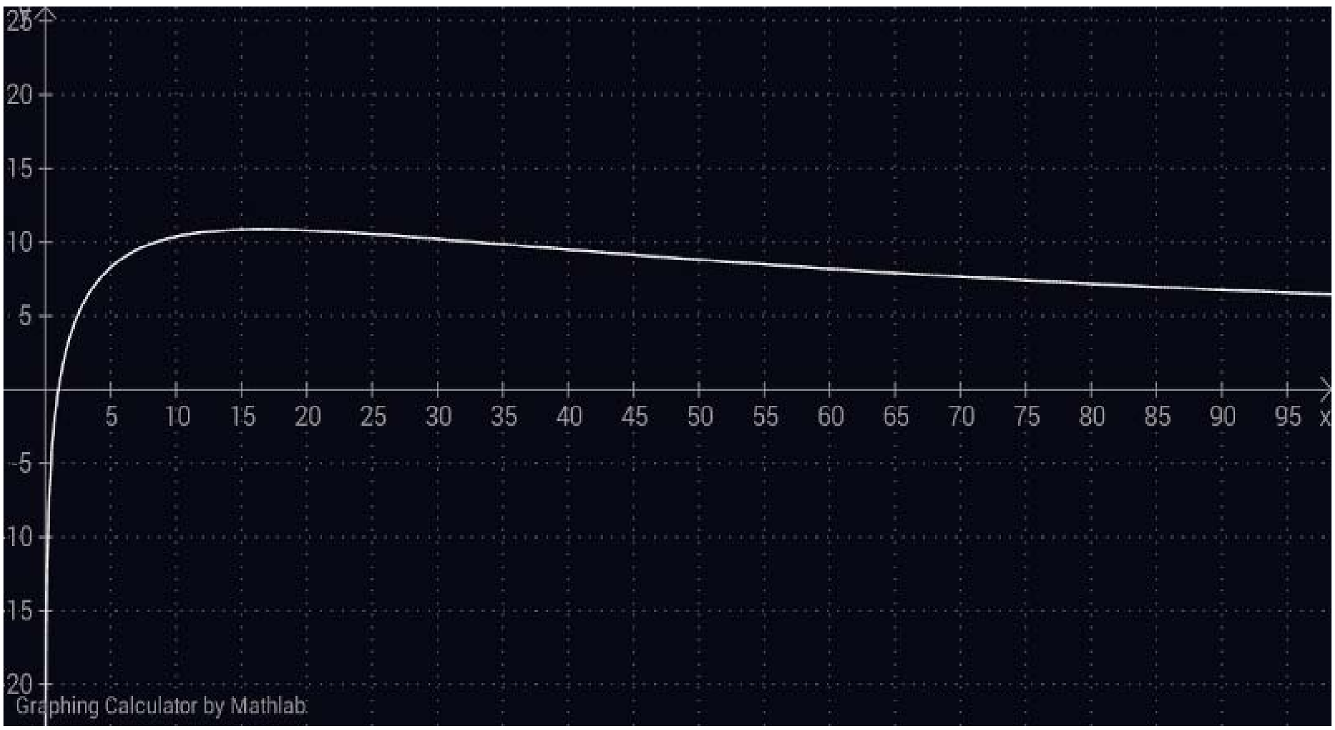
Nuclear Binding Energy Curve

Abstract: An empirical formula is found for nuclear binding energy per nucleon that agree well with observations from atomic number Z=14.The interpretation indicates that we need to explore physical variables involved in the nuclear force or nuclear binding energy.

The equations for nuclear binding energy curve are of the form

$f(x)=180\log x/(x+30)$

The graph of f(x) versus x is shown below.



This smooth curve is similar to the nuclear binding energy curve except for atomic numbers in the range from Z=1 to Z=13. In the nuclear binding energy curve it is not smooth in the range Z=1 to Z=13.

It is assumed that nuclear binding energy per nucleon is distributed equally among the nucleons. We can express the equation for nuclear binding energy curve from atomic number Z=14 as

$E=k\log x/(ax+c)$

x is the mass number. Here a and c are dimensionless constants and k is a physical constant and has dimensions of energy..

For mass number x=1, then E=0. As mass number $x\rightarrow\infty$ then nuclear binding energy per nucleon $E\rightarrow 0$

We can express the equation as $E=(k/a)\log x/(x+c/a)$

For atomic number Z=14, the element is 14Si28

The iron has high nuclear binding energy and stability is also high. To find the constants k/a and c/a, we consider the element iron 26Fe56 and the last stable element lead 82Pb208.

The nuclear binding energy per nucleon for iron of mass number x1=56 is E1=8.790323 MeV and for lead of mass number x2=208 is E2=7.86745 MeV.

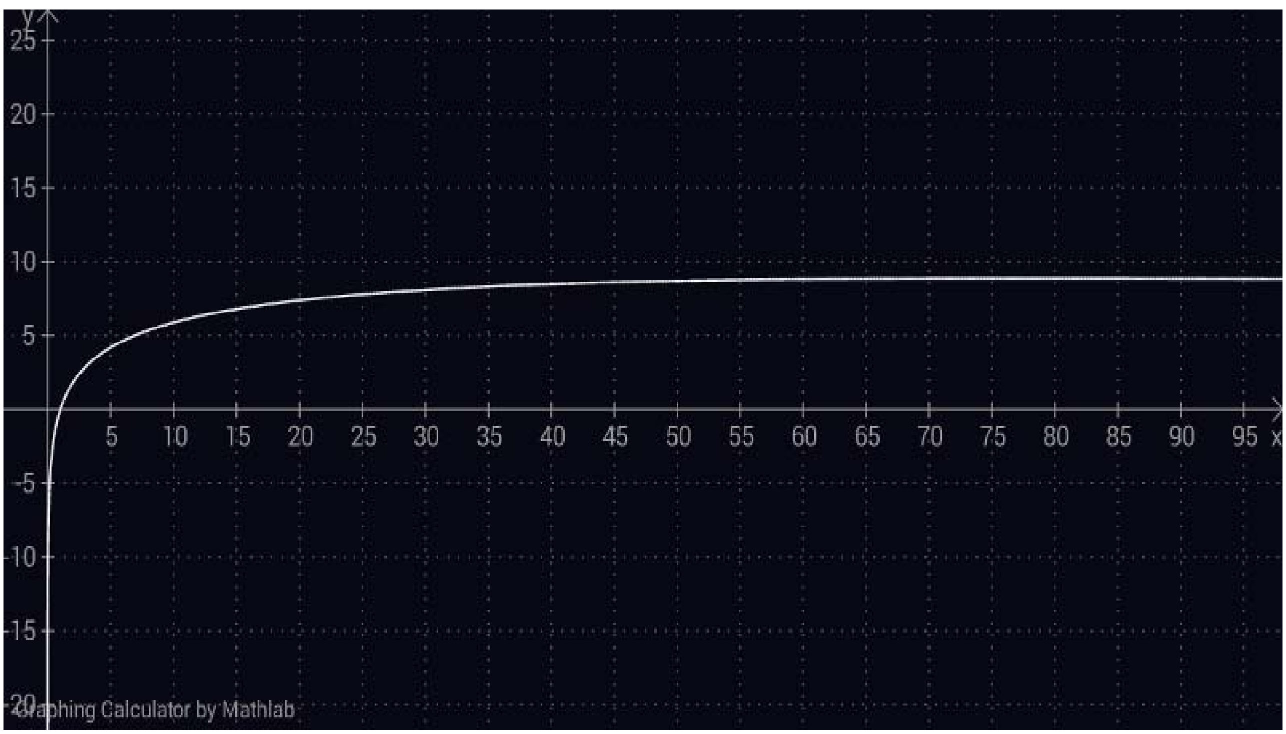
E1/E2 yields   c/a=259.665982

Now E1E2 yields k/a=689.332549 MeV

Therefore the equation for nuclear binding energy curve is

$E=(689.332549)\log x/(x+259.665982)$

The graph of binding energy per nucleon versus mass number x is shown below.



This equation fits well in the atomic number ranges from Z=14 ie 14Si28.

It is found by calculations that the variation of binding energy per nucleon obtained by the empirical formula with the actual binding energy per nucleon is between -4% to 3% Here -4% means the binding energy per nucleon obtained by the empirical formula is 4% less than the actual binding energy per nucleon and 3% means the binding energy per nucleon obtained by the empirical formula is 3% more than the actual binding energy per nucleon.

The range of atomic numbers from Z=1 to Z=13 the empirical formula fits if and only if we consider the multiplication factor that varies between 1.18 to 1.9

The above interpretation indicates that the discrepancy between the empirical formula and the actual nuclear binding energy curve.Therefore we need to explore the physical variables that are involved in the nuclear force or nuclear binding energy.

References:

1) Wikipedia