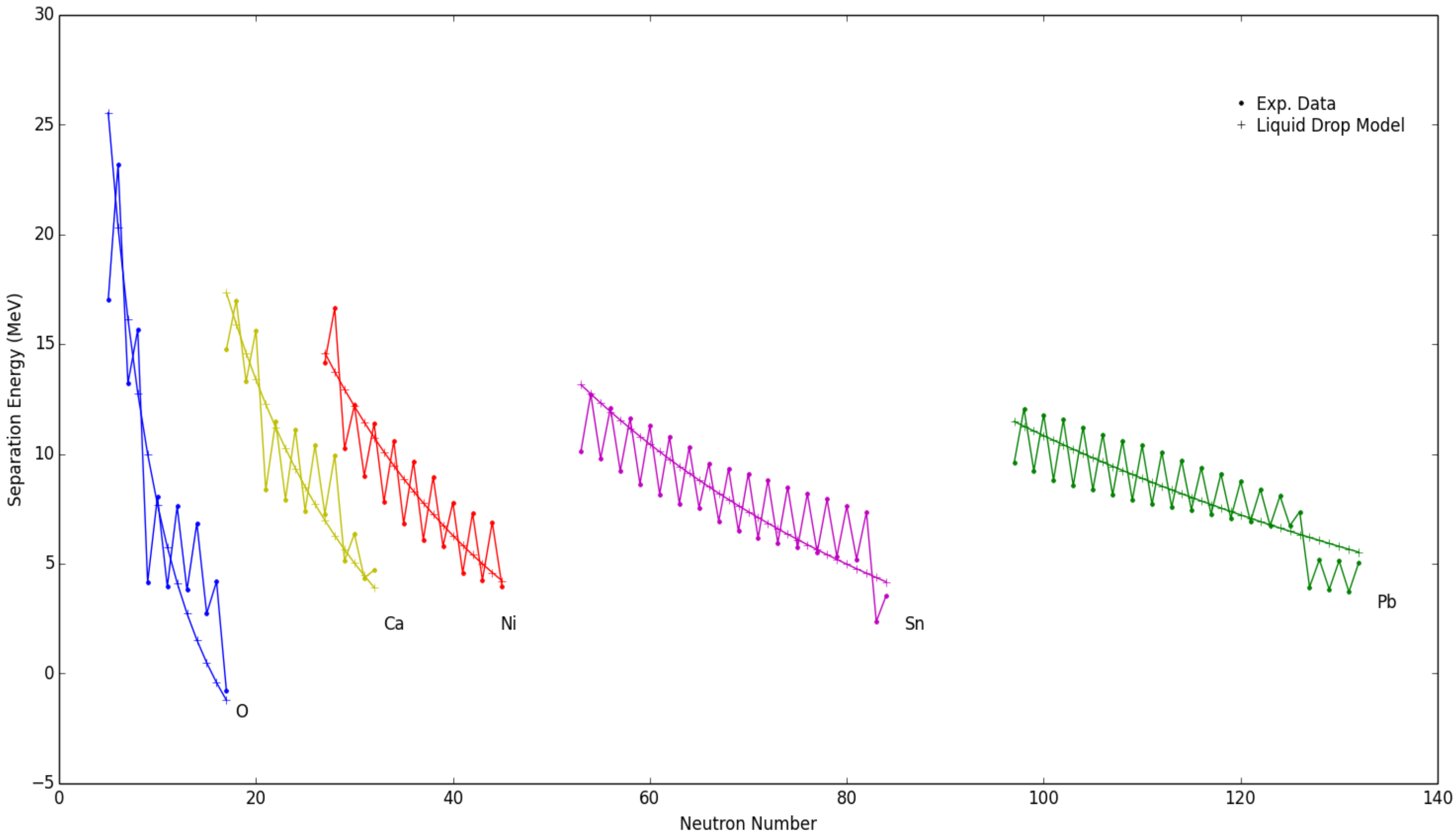
Maxwell Cao (Yuchen) PHY981 Ex. 1 Jan 21st 2016

1. Separation energy of Oxygen, Calcium, Nickel, Tin and Lead isotopes vs. neutron number



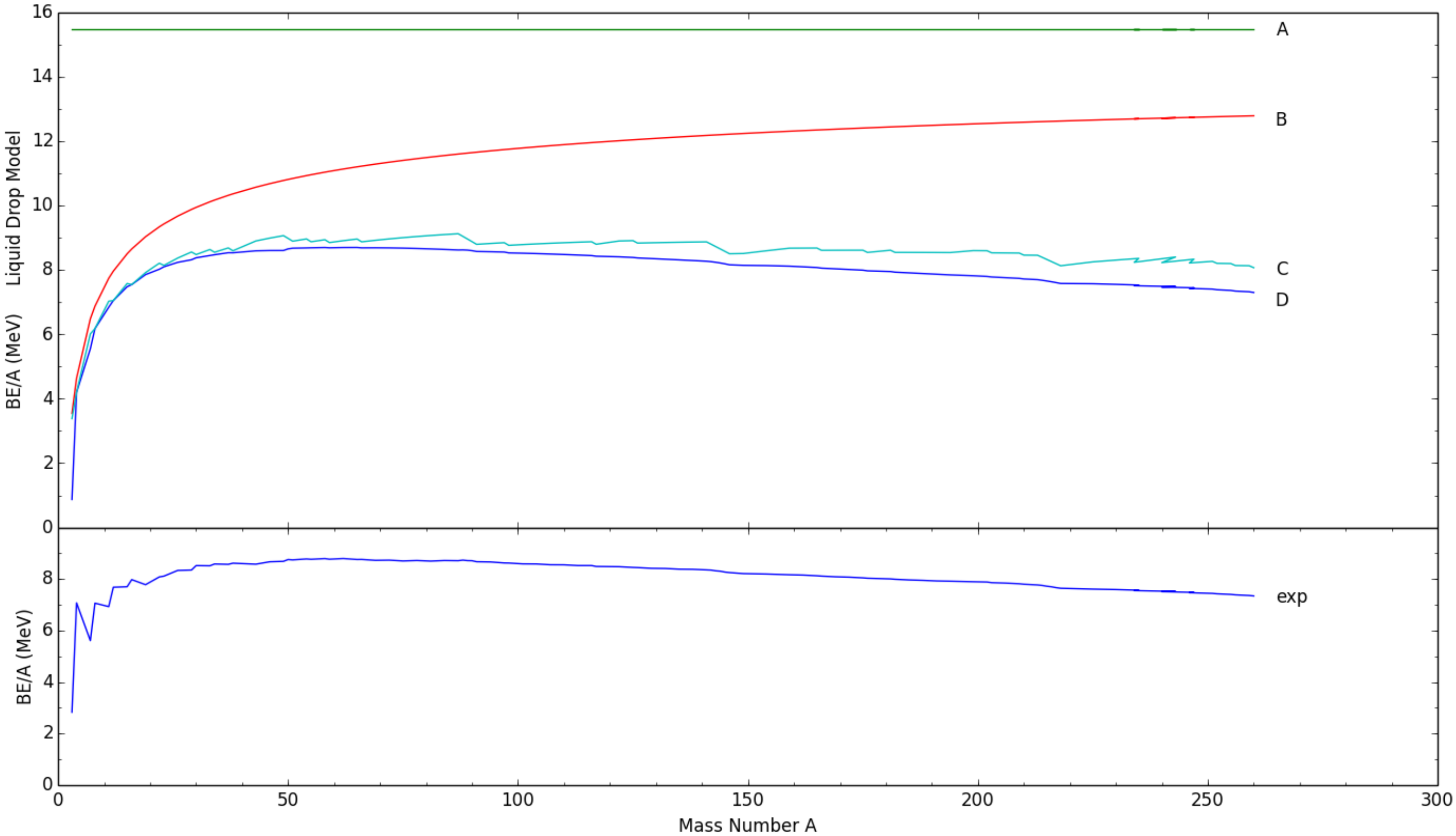
1) For all these isotopic chains we can see from the experimental data that there are staggering effects in the separation energy, which is mainly caused by pairing in even-even nuclei, the separation energies are higher in the even-evens.

2) For the liquid drop model (LDM) given in this exercise, there is no paring term, therefore we don't see the same staggering in the data produced by the LDM equation.
In both data, we can see separation energy decreases as neutron number increases, this is due to the over abundance of neutron, closing in to the neutron drip line, where the nucleus becomes less stable, it is reflected by the asymmetry energy term in the LDM.

3) For doubly magic nucleus, the binding energy is higher than 'usual', due to the increased stability of full shell.

4)Some of the experimental data (and hence I only used LDM calculated data up to the same isotopes) here does not actually go as far as the predicted neutron drip line, because there are currently no experimental data on those isotopes, the end nucleus of each isotopic chain aren't all neutron drip line nucleus.

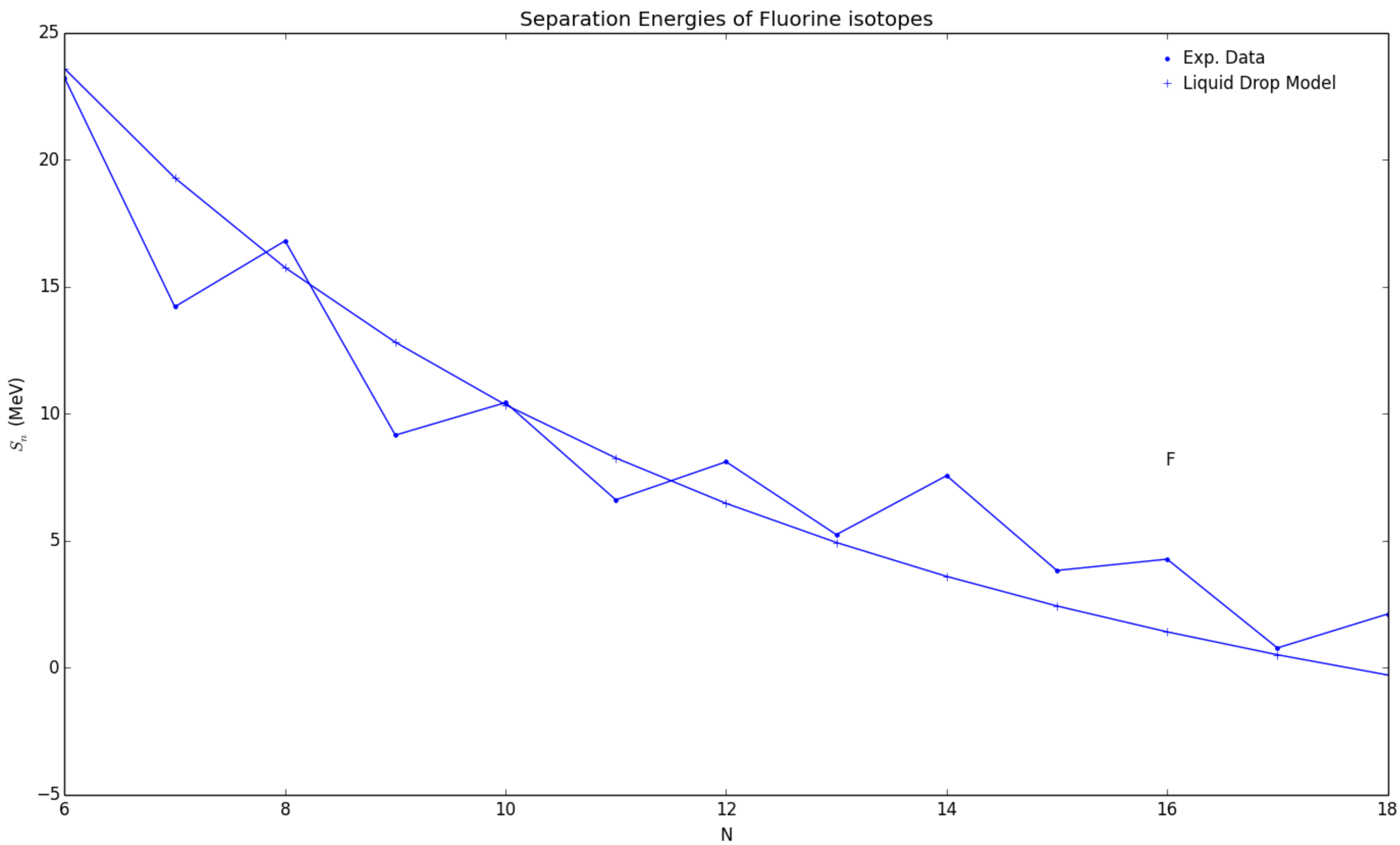
2. Binding energy per nucleus vs. mass number.
Top plot: A) LDM with only volume term, B) LDM volume + surface terms, C) LDM volume + surface + Coulomb terms, D) All terms in given LDM equation.
Bottom plot: experimental binding energy per nucleus



Line A demonstrates the LDM volume term is linear with mass number A,
Line B demonstrates the decrease of binding energy due to surface term,
Line C shows that the Coulomb term constraints the nucleus even more, as the protons repels each other,
Finally line D adds the asymmetry term, which balances the neutron & proton number.
The resulting line D is very similar to experimental data, from the shape and from the value of the largest BE/A that both shown to be ~8 MeV.

All elements (Z number) from bedata.dat appears in the top plot calculation, then by comparing among the isotopes within the element, I chose the one that has the highest BE/A and used this pair of (Z,N) to plug into the LDM equation.

3. Separation energy vs. neutron number in Fluorine isotopes



This plot demonstrates similar behavior to the first plot in this exercise, the main thing that's worth bringing up is that the predicted drip line by the given LDM equation stops at F-26, but the experimental data shows F-27 also has a positive separation energy and is somewhat more stable than F-26.

Again, this is due to the missing pairing term in the given LDM equation, while Fluorine has an odd number of protons, we can see the neutron pairing effect itself can gain a higher binding energy, regardless of the oddity of proton number, this shows that in a nucleus, neutrons and protons also have separate collective behavior/ effect and can behave differently.