Problem #1: Why does the binding energy per nucleon increase with increasing atomic mass number (A) for small values of A? Why does the binding energy per nucleon decrease with increasing atomic mass number for large values of A?

For small values of A, the strong force dominates and pulls the nucleus into a "more tightly bound" state as A increases. (More nucleons are there to attract each other).

As A gets too large, the electromagnetic force "overtakes" the strong force because the protons begin to repel each other. The nucleons are pushed out into a "less bound" state.

"more tightly bound" = more binding energy
"less tightly bound" = less binding energy
Problem #2: Pohl #11.5: Why does Carbon-12 have a greater binding energy than Nitrogen-12?

- Carbon has 6 p & 6 n.
- Nitrogen has 7 p & 5 n.

The Coulomb repulsion for Nitrogen is higher, then the nucleus is “less bound”, and has less binding energy.
Problem #3: Rohr11.11: Calculate the binding energies of $^{55}$Fe, $^{57}$Co, and $^{58}$Ni. Compare the actual binding energies to the Weizsaecker formula of the liquid drop model.

Weizsaecker liquid drop: $E_b = (15.75 \text{MeV})A - (17.8 \text{MeV})A^{2/3} - \frac{0.71 \text{MeV}^2}{A^{1/3}} - 23.3 \text{MeV}\left(\frac{A}{14}\right)^{1/3}$

$^{55}\text{Fe} \rightarrow E_b^{\text{even-odd}} = (15.75 \text{MeV})55 - (17.8 \text{MeV})55^{2/3} - \frac{(0.71 \text{MeV})(26)^2}{55^{1/3}} - \frac{(23.7 \text{MeV})(55-2.27)^2}{55}

= (866.25 - 257.43 - 126.38 - 3.88 = 478.56 \text{MeV})$

$^{57}\text{Co} \rightarrow E_b^{\text{even-odd}} = (15.75 \text{MeV})57 - (17.8 \text{MeV})57^{2/3} - \frac{(0.71 \text{MeV})(27)^2}{57^{1/3}} - \frac{(23.7 \text{MeV})(57-2.27)^2}{57}

= (897.75 - 263.64 - 134.68 - 3.74 = 495.69 \text{MeV})$

$^{58}\text{Ni} \rightarrow E_b^{\text{even-even}} = (15.75 \text{MeV})58 - (17.8 \text{MeV})58^{2/3} - \frac{(0.71 \text{MeV})(28)^2}{58^{1/3}} - \frac{23.7 \text{MeV}(58-2.28)^2}{58} + \frac{11.18 \text{MeV}}{\sqrt{58}}$

= 913.5 \text{MeV} - 266.71 \text{MeV} - 144 \text{MeV} - 1.63 \text{MeV} + 1.47 \text{MeV}

= 502.63 \text{MeV}
Actual Value:  $E_b = 2m_p c^2 + (A-2)m_n c^2 - M c^2$

$^{55}\text{Fe}$  
$E_b = 2(938.27 \text{MeV}) + 79 (939.57 \text{MeV}) - 51161.8 \text{MeV} = 480.75 \text{MeV}$

$^{57}\text{Co}$  
$E_b = 27(938.27 \text{MeV}) + 30 (939.57 \text{MeV}) - 53022.5 \text{MeV} = 497.89 \text{MeV}$

$^{58}\text{Ni}$  
$E_b = 28(938.27 \text{MeV}) + 30 (939.57 \text{MeV}) - 53952.6 \text{MeV} = 506.06 \text{MeV}$
Problem 14: Rohl 11.12: Why are there \( \beta^- \) decays in the four radioactive series? Why are there no \( \beta^+ \) decays?

\( \alpha \) decays reduce the number of neutrons and protons equally. The nucleus becomes neutron rich making \( \beta^- \) decay more likely in order to rid the nucleus of neutrons and increase stability.

\( \beta^+ \) would be the opposite; it would just make the nucleus unstable. It won’t happen for this reason.