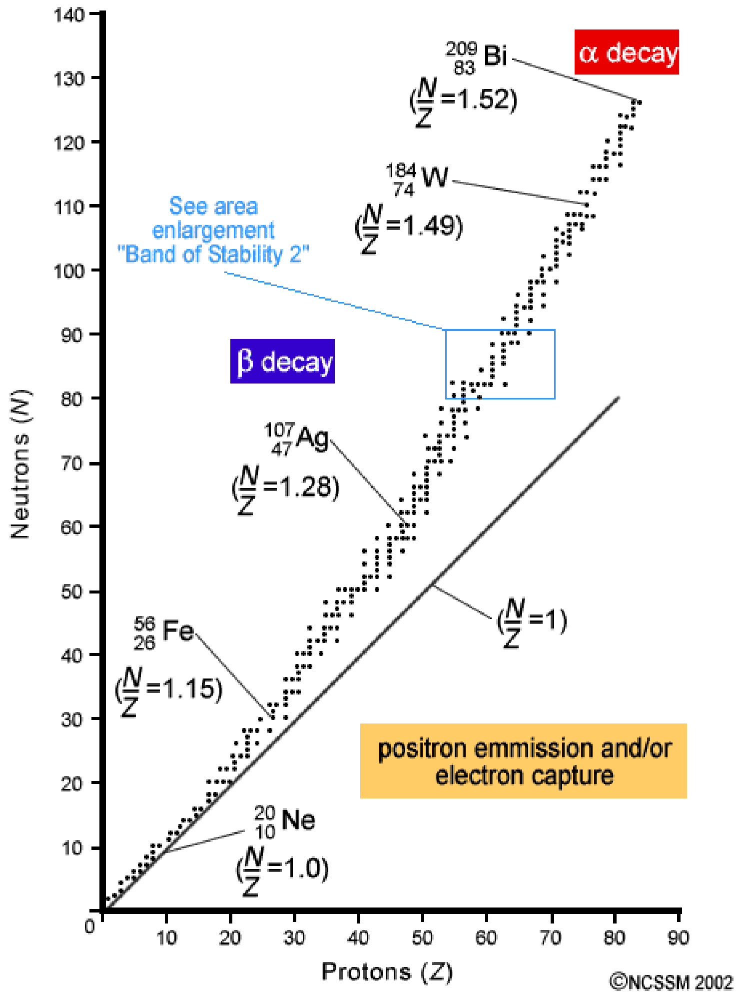
Discussing Nuclear Stability

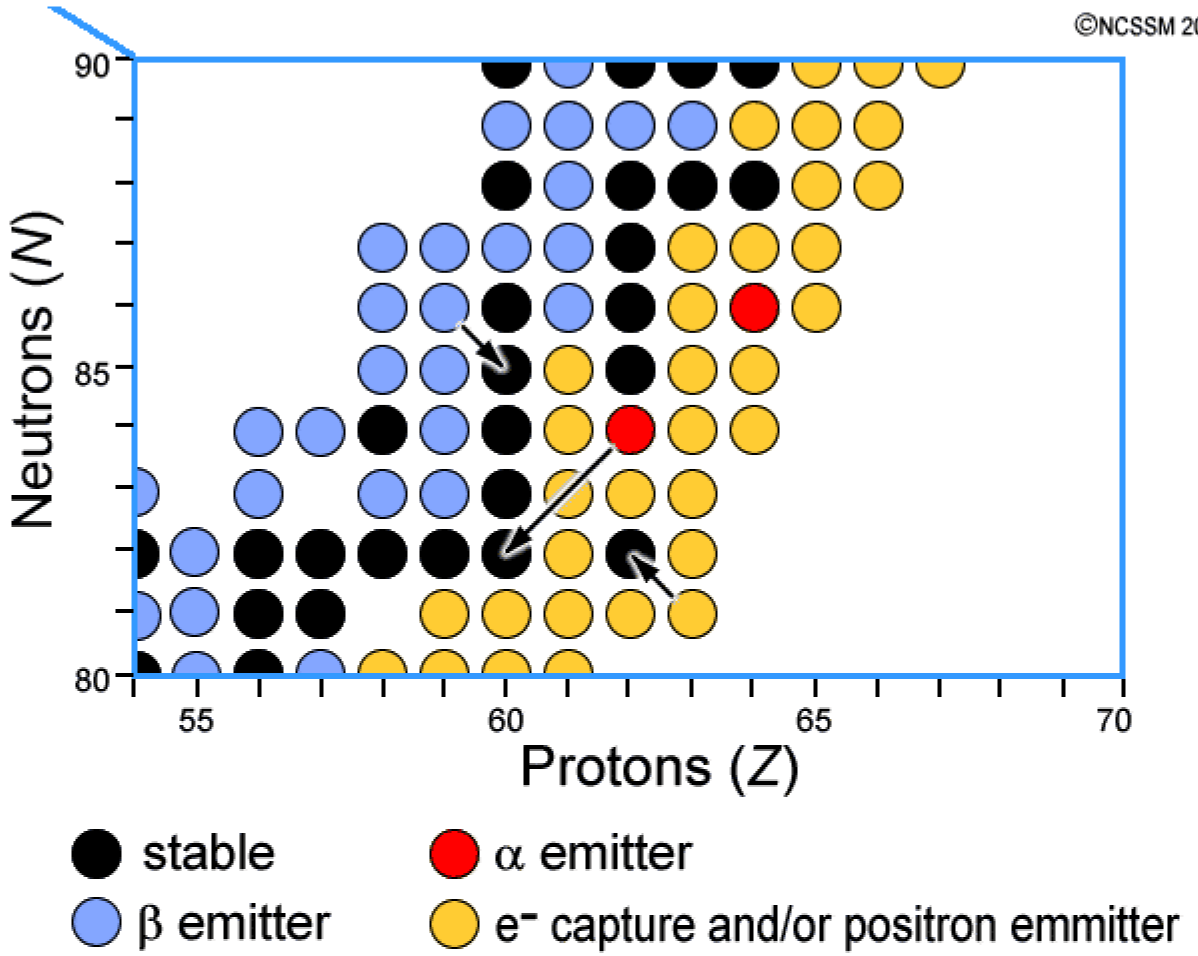
Bromfield Honors Chemistry

3 ways to discuss nuclear stability

- "Band of stability"
  - 1:1 ratio of neutrons: protons



Close up view

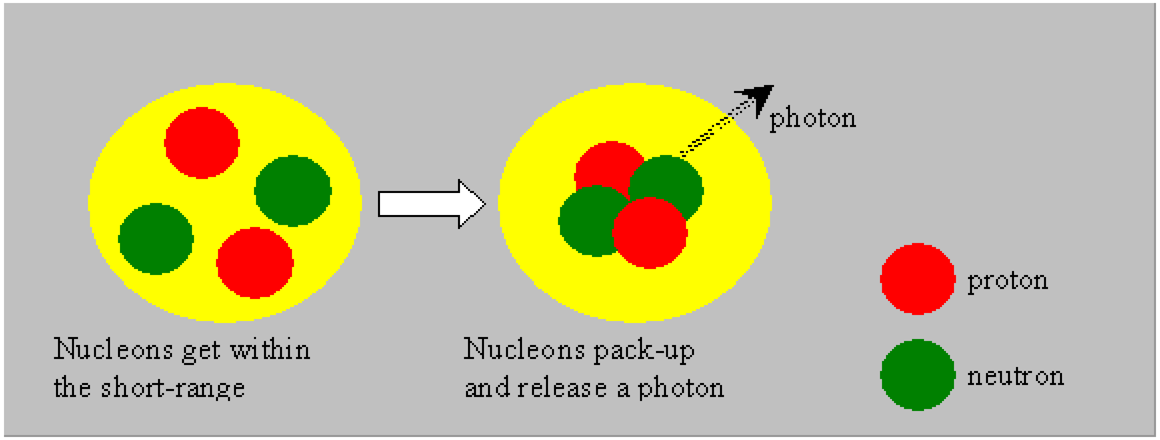


3 ways to discuss nuclear stability

- The most stable atoms have even numbers of protons and even numbers of neutrons.
- "magic numbers"

3 ways to discuss nuclear stability

- 3. Binding energy



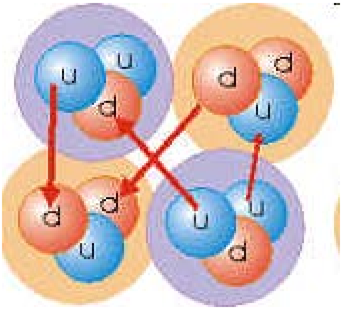
3 ways to discuss nuclear stability

- 3. Binding energy

- …but first we need to review the forces at play in the nucleus

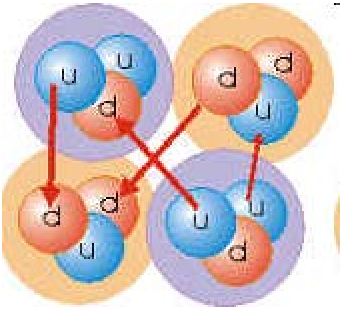
Strong force (nuclear force)

- All nucleons attract one another



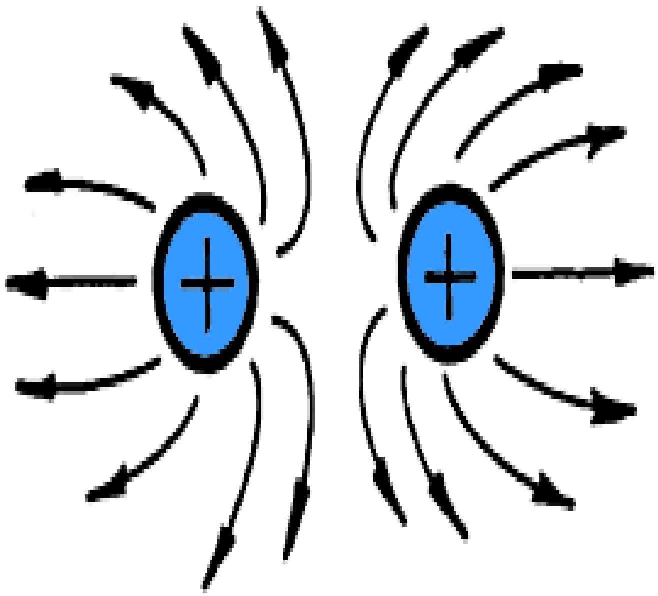
Strong force (nuclear force)

- All nucleons attract one another
  - Most effective over short distances



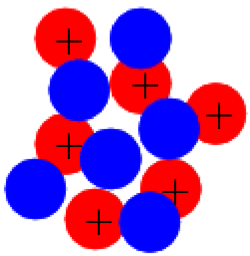
Repulsive forces

- Like charges repel, so the protons in the nucleus repel each other.

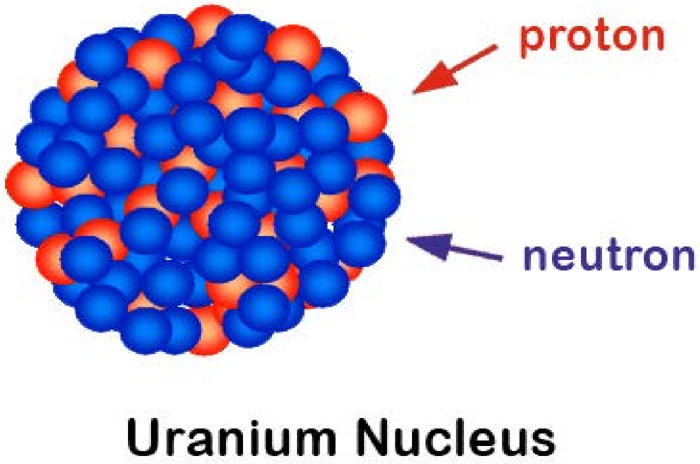


Small vs. large nuclei

- Small nucleus



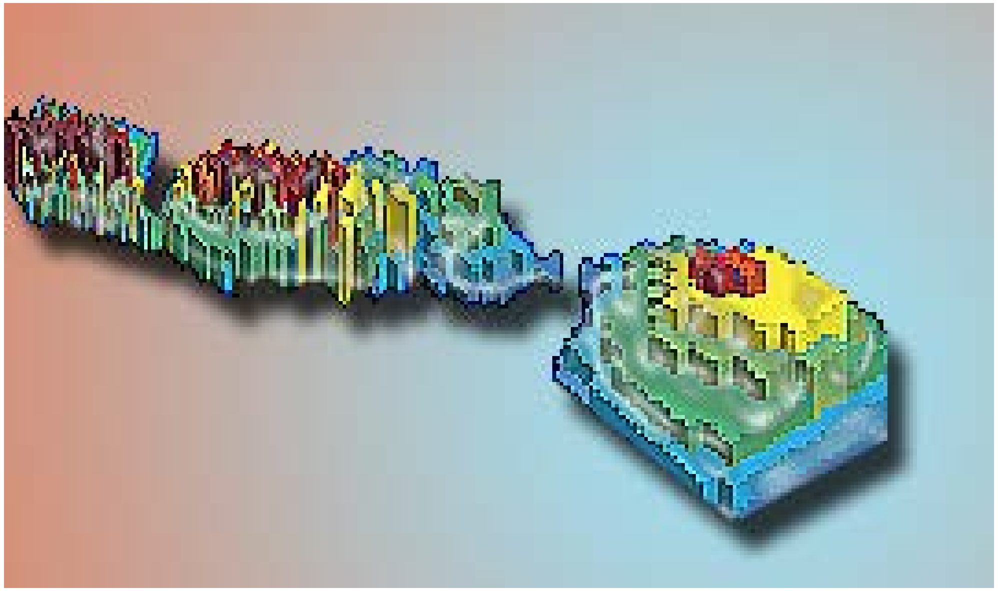
- Strong force > repulsive force



- Repulsive force > strong force

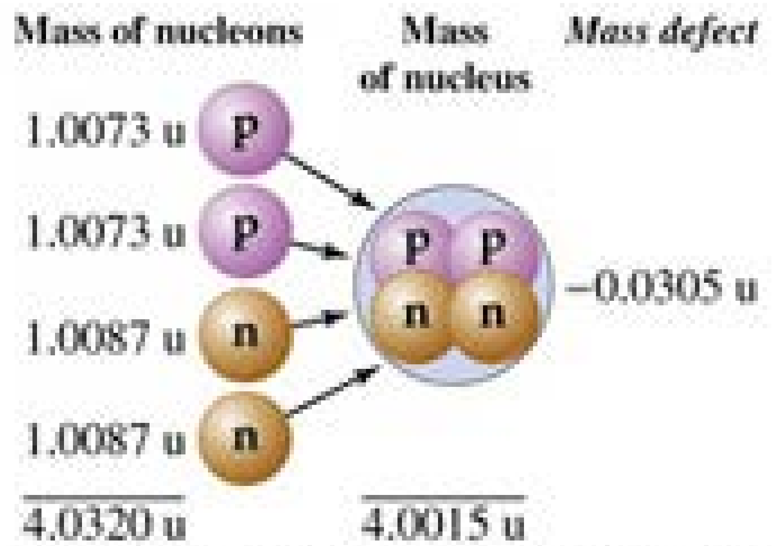
Video

- The Island of Stability



Mass Defect

- The actual mass of a nucleus is LESS than the combined mass of the isolated protons and neutrons



Calculate the expected mass for the ^{16}O nucleus

- Mass of an isolated proton = 1.0078252 amu
- Mass of an isolated neutron = 1.0086642 amu

Calculate the mass defect for ^{16}O nucleus

- Mass defect = expected mass – actual mass

Calculate the binding energy

$E = mc^2$

1 amu = 1.66050x 10^{-27} kg

$$J = \frac{kg \bullet m^2}{s^2}$$

Calculate the binding energy/nucleon

Why do we care?

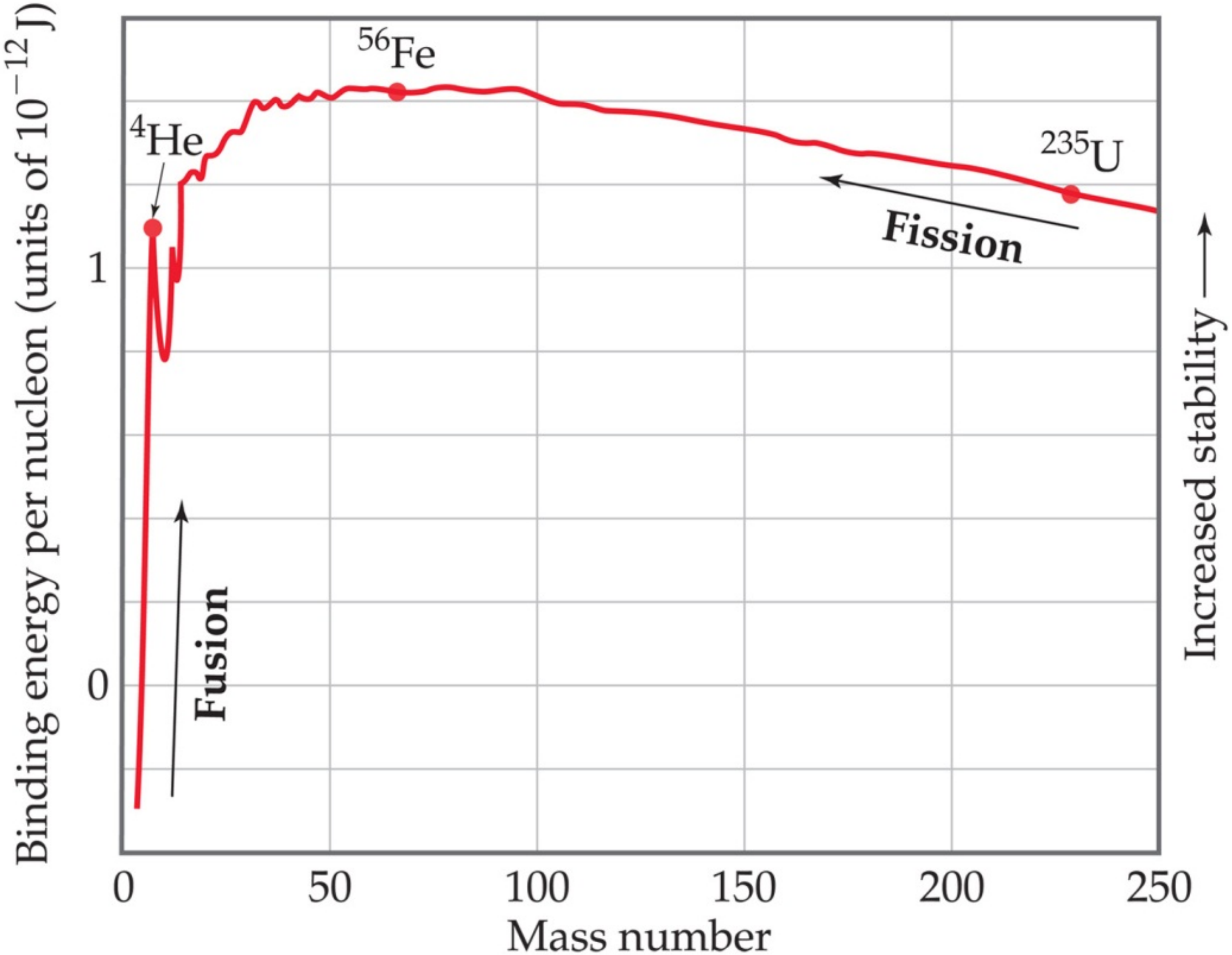
- Higher binding energy per nucleon $\Rightarrow$ more stable nucleus!

Using binding energy

- Which of the following is the most stable?

Nucleus	Binding Energy per Nucleon (J)
$^{4}_{2}He$	1.13×10^{-12}
$^{56}_{26}Fe$	1.41×10^{-12}
$^{238}_{92}U$	1.21×10^{-12}

Which element is most stable?



Protons and neutrons do not have the same mass in every nucleus.