Announcements

• There will be a quiz Wednesday, April 18th.
• Homework #5 is due Tuesday evening.
• In addition to my normal office hours today, I will also hold office hours this evening from 6:30pm until 9pm. On Tuesday I will have office hours from 10am until noon.
• The midterm solutions are posted and Lecture 31 (from last Friday) is also posted.
• Homework #2 is graded and posted.
• The correct time and date for the final exam are May 4th, from 9AM to 12 noon.
Nuclear weapons and nuclear reactions
(Chapter/section 16.1)

• The atomic nucleus
• Different isotopes of the same element
• Fission reactions
• Fusion reactions
The atomic nucleus

• An atom’s size is a few x $10^{-10}$ meters
• An atomic nucleus’ size is a few x $10^{-15}$ meters
• The nucleus contains both protons and neutrons.
• The number of protons (which is also equal to the number of electrons) determines which element the atom is.
• The number of neutrons determines which isotope of the element the atom is.
Different isotopes of the same elements

• Cesium-133 is the most common isotope of cesium, and it is stable.
• Cesium-137 is radioactive, and undergoes what is called “beta decay” to become barium-137.
• In beta decay, one of the neutrons emits a beta particle, which is essentially an electron, and becomes a proton.
• With one less neutron and one more proton, barium 137 is stable.
The strong or nuclear force

• Extremely attractive at very short distances. Virtually nonexistent at distances as short as several proton diameters.
• The strong force tends to hold a nucleus together, but all the protons repel one another and try to tear it apart.
• For any given number of protons, certain numbers of neutrons result in a stable nucleus, while other numbers result in an unstable nucleus.
Building a nucleus
(the path to lower potential energy)

The strong force acts to hold the nucleons together

<table>
<thead>
<tr>
<th>More protons</th>
<th>More neutrons</th>
</tr>
</thead>
<tbody>
<tr>
<td>Potential energy increases as you add protons because of electrostatic repulsion.</td>
<td>Potential energy decreases as you add neutrons. (They act as spacers keeping the positively charged protons further apart.)</td>
</tr>
</tbody>
</table>

At some point, though, it becomes energetically favorable for a neutron to turn itself into a proton, which is less massive. This is beta decay.

- In beta decay, a neutron transforms into a proton, emitting a beta particle (a high energy electron) and a neutrino in the process.
The optimal ratio of neutrons to protons is 1:1 at low atomic numbers, but climbs substantially for heavier elements.
The maximum binding energy per nucleon, and thus the most stable nucleus, corresponds to iron.