Lecture 1.3 Unclear Points:

I am not sure how to solve #2 of the pretest.

You should be aware that typical K-shell binding energies for mid-sizes atoms are on the order of a few keV.

When you are asking "binding energy of an electron" are you asking about the nuclear binding energy or the binding energy $E_b$.

$E_b$

More less what is the difference between the two

Nuclear binding energy is the energy required to remove a nucleon from a nucleus, while electron binding energy is the energy required to remove an electron from an atom.

Understanding nuclear fission and fusion.

For small nuclei, the average binding energy per nucleon increases with increasing Z, so small nuclei undergo fusion. For large nuclei, the average binding energy per nucleon decreases with increasing Z, so large nuclei tend to undergo fission.

What is the relation between the surface to volume ratio and critical mass?

Number of neutrons ejected from a mass of fissionable material will depend on surface area, while number of neutrons produced will depend on volume.

Was question 2 asking for the binding energy in k shell of tungsten or technetium?

For quizzes and tests, will we be expected to memorize conversion factors (such as Ci to Bq, hp to watt, eV to J, etc.) and constants (such as particle masses)?

This information will be provided to you.

Am I correct in assuming that Technetium will have a lower binding energy than tungsten, but not so much lower that it will fall out of the KeV range?

K-shell binding energy for technetium is 21.0 keV
[http://www.webelements.com/technetium/orbital_properties.html]

Why are the number of electrons per K,L,M shell different from the magic nucleon numbers? (The third electron shell holds 18 electrons while the third magic nucleon number is 20).

Electron “magic numbers,” indicating filled shells are 2, 10, 18, ..., with loosely-bound electrons (highly-reactive elements) for Z=3, 11, 19, etc. Nucleon magic numbers are 2, 8, 20, 26, etc., with 3rd, 9th, 21st, 29th, etc., nucleon loosely bound. Different quantum numbers because
potential in nucleus is different from that in atom. Atom as $1/R^2$ potential, whereas nuclear force can be modeled by square well potential.

The concept of the Auger electron is still not completely clear. Can it be emitted from any shell in the atom?

As long as energy of characteristic x-ray greater than binding energy of electron.

Review kerma vs dose.

Why we cannot have more than eight electrons in the outer shell? I mean why the stability occurs in this situation?

Primarily a matter of energy considerations.

Would the reasoning be that Technetium, being close to Tungsten on the Periodic, but having less protons, should have a binding energy that is: (1) less than Tungsten's which is approximately 69 keV, (2) but in the same range, such as in the keV range?

Yes.

I'd like to know how about the critical mass calculation you mentioned.

Number of neutrons produced is related to mass of fissionable material, number of neutrons escaping is related to surface area. If the mass is too small, too many neutrons escape the fissionable material to maintain a chain reaction.

The Mayer shell model of discrete energy levels in the nucleus - is that proven out and what is the idea behind it - what is filling the shells?

Experimental observation of “magic numbers,” extremely stable nuclei corresponding to filled shells. Shells represent energy levels that are filled in accordance with exclusion principle. Potential used is similar to three-dimensional harmonic oscillator with spin-orbit interaction.

On the N/P ratio used as a measure of stability - this is very interesting. it is not obvious to me why this is so. Can you help me with get a grasp on this intuitively? Is a 1:1 ratio the best balance? Thank you.

Balance between Coulombic force repelling protons and strong nuclear force attracting protons and neutrons. For large nuclei, strong force cannot overcome Coulombic force, so more neutrons are needed to keep protons apart.

The nuclear fission process was not very clear to me. What exactly is a slow neutron?

Slow neutrons – a few eV
Is there any justification for the fact that even numbers of nucleons give rise to more stable atoms? Similarly, why does a p/n ratio closer to 1 give rise to more stable atoms (in other words, why do atoms tend towards equal numbers of protons and neutrons)?

Even numbers – pairing of spins

In general and organic chemistry courses, isomers refer to a molecule with same chemical formula but different chemical structure. But in the lecture, do isomers refer to single atoms of same element but different within different energy states? How would that happen?

Isomers mean different things in chemistry vs nuclear physics. Isomeric nucleons are those of excited energy state with measurable lifetimes.

I am not clear why Auger electrons have to be emitted when some outer shell electrons go to inner shell. Also, are those Auger electrons from inner shell or outer shell?

When an outer shell electron goes into an inner shell, energy is given off. This energy can be either in the form of characteristic x-rays or Auger electrons. If the energy of the transition is less than the binding energy of any of the bound electrons, then Auger electrons will not be ejected.

I would love further details regarding the timing and relationship between the creation and filling of holes and the production of characteristic x-rays and Auger electrons.

A discussion of time-dependence of characteristic x-ray production would be beyond the scope of this course.

I’m still a little confused about how the magic numbers are determined. For the plot of binding energy/mass number vs. atomic number, are the nuclei represented the most stable nuclei? Because for a given Z, there are multiple possible nuclei.

“Magic numbers” are the result of filled electronic or nuclear shells. Generally, if a magic number is reached, the atom or nucleus will be most stable.

Experimental observation of “magic numbers,” extremely stable nuclei corresponding to filled shells. Shells represent energy levels that are filled in accordance with exclusion principle. Potential used is similar to three-dimensional harmonic oscillator with spin-orbit interaction.

If a large nucleus fissions into two smaller nuclei (each of which has more binding energy/nucleon), does that mean the total binding energy in the system increases making fission an endothermic process?

The nuclear binding energy is a function of the rest masses of the nuclei, which have to be taken into consideration when determining the energy emitted in fission.

What is the significance of a "spin quantum number" and what role does it play in describing the electrons?
Spin is an intrinsic property of electrons and is a form of angular momentum that couples with the orbital angular momentum.

Talking about Nuclear spin, could you please give a convincing argument on why a nucleus gets highly unstable when it tends to possess odd number of both protons and neutrons?

Greater stability when spins are opposed to each other.