FYS 3520 Kjernefysikk, struktur og spektroskopi
Midterm Examn 2013

1. A nucleus has given mass 166.932046 nuclear mass units (u)
Calculate the binding energy
Which nucleus is it? Write the chemical name, Z and neutron number.

2. Calculate the binding energy by means of the semi empirical mass formula (Weizsäcker). Use the standard values of the coefficients given in the textbook.
How does the result fit with what you found in question 1?

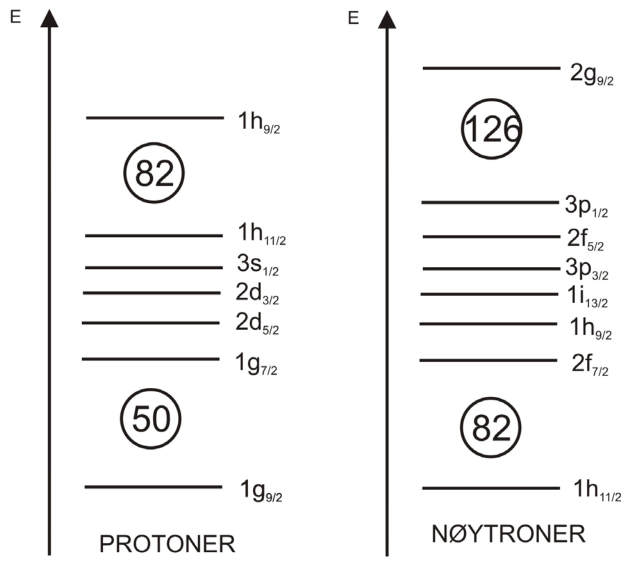
3. We will study some medium mass nuclei:
$_{58}$Ce (Cerium), $_{59}$Pr (Prosedymium), $_{60}$Nd (Neodymium), $_{61}$Pm (Promethium), $_{62}$Sm (Samarium), $_{63}$Eu (Europium), $_{64}$Gd (Gadolinium), $_{65}$Tb (Terbium), $_{66}$Dy (Dysprosium), $_{67}$Ho (Holmium), $_{68}$Er (Erbium).

These nuclei belong to the family ”rare earth elements”. Find how many stable nuclei there are of these elements. How do the stable nuclei depend on the number of protons and of neutrons? Explain what you see.
How do the unstable nuclei decay? Make a part of the nuclear chart (N versus Z).

The rare earth nuclei form a part of the nuclear chart with stable deformations. The exceptions are nuclei with proton number or neutron number close to magic numbers. Are any of the nuclei above well deformed nuclei? See figure at p. 137 in the textbook.

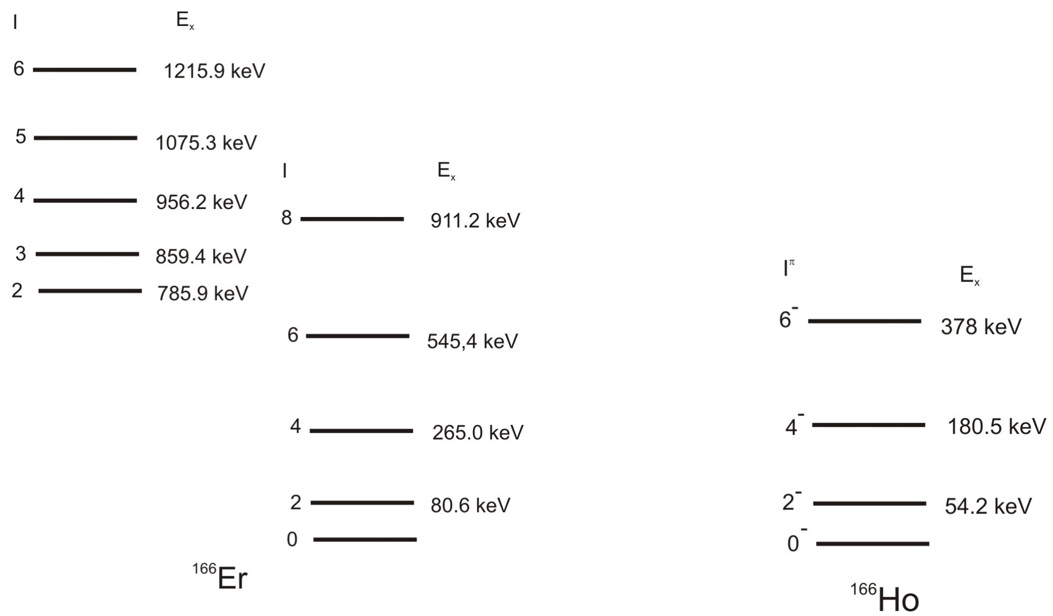
4. All nuclei with an even number of protons and even number of neutrons have $I^{\pi} = 0^{+}$. Why?
Determine the spin and parity of the ground state for the stable odd-A nuclei in question 3. How can spin and parity be found from the shell model? Use the level schemes shown below.
Are there some nuclei that cannot be explained with this model? Which and why.

Can you from the given masses estimate the pair-gap parameter Δ for this section of the nuclear chart?




5. Excited states in even-even nuclei can be explained by placing two identical particles in the same shell model state. Show the possible spins that occur with two neutrons in the shell model state $1h_{9/2}$.

6. Below are shown the ground bands in $^{166}$Er and $^{166}$Ho. What kind of nucleus is $^{166}$Ho? How can it be produced?




Are these nuclei good rotors? Explain.

The ground band in $^{166}$Ho has negative parity. How can we explain that?
Calculate the rotation constant and the moment of inertia from these rotation bands.
The excited bands in $^{166}$Er decay to the ground band by emission of gamma-radiation. Propose the most probable transitions and explain why?

7. We can make nuclear reactions in the laboratory by bombarding the nuclei in a target with a beam of charged nucleons with high energy. If the beam consists of e.g. alpha-particles, the speed must be sufficient to overcome the Coulomb barrier. How can we calculate the Coulomb barrier? Which energy should the alpha-particles have in order to penetrate $^{152}$Sm.

Good luck!
John Rekstad