**Master on Nuclear Engineering. FNE_RP**

Threshold Exam Number 1. 2014 – 10 – 23

Full Name: ___ ___ ___

1. Write the equations for energy conservation in a decay of one parent yielding two ejectiles. What masses should be used in this equations?

$X \rightarrow a + b$ $\qquad M'_x c^2 + E_x = M'_a c^2 + M'_b c^2 + E_a + E_b + E^*$

$M'_x$: we use the nuclear masses (but they are not tabulated so we will have to transform them to atomic mass tabulated)

$E_x$ = 0: we consider it a stop at the begining

$E_a$, $E_b$: kinetic energies

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2. What is the meaning of a microscopic cross-section? — at a given energy.

The microscopic cross-section ($\sigma$) is the actual area ~~representing~~ where particules have a specific interaction with the studied particule. The total cross-section represents the area where any interaction can happen.
$\sigma$ is always larger than the area of the particle (or nucleus) studied.

flux → ; $\sigma$ (area where they interact) ; A ; don't interact

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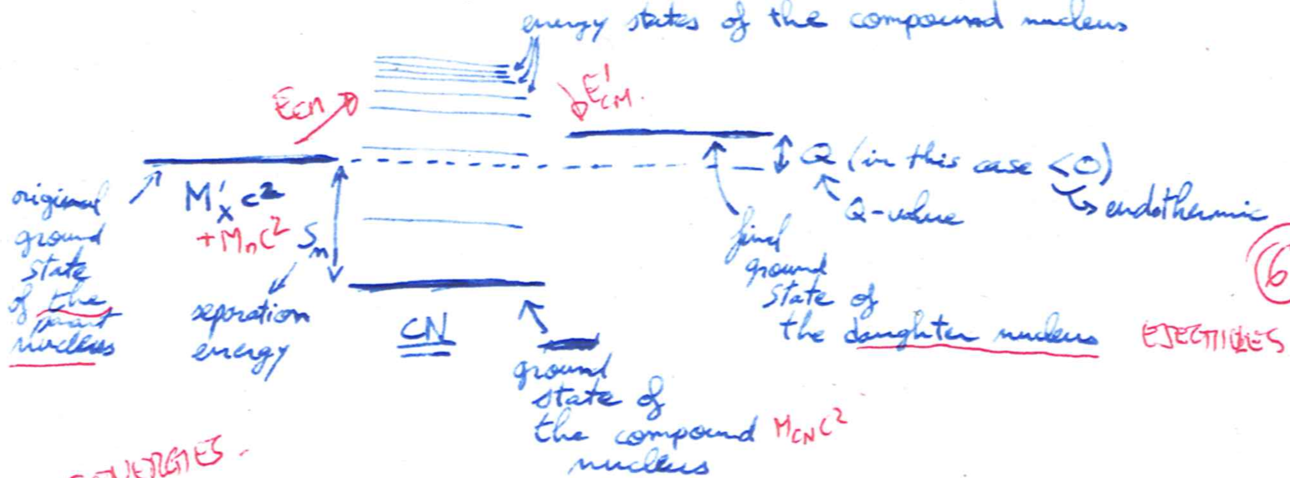
3. Draw the energy diagrams of a (neutron induced) nuclear reaction going through a compound nucleus. Indicate what the main magnitudes in the diagram are

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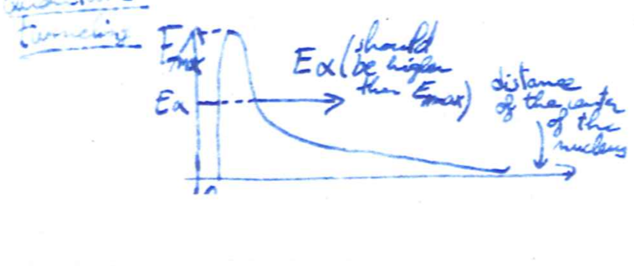
4. How are the energies of alpha particles emitted in the decay of a typical alpha-emitter? Give a short explanation. — DISCRETE ENERGIES.

$^{A}_{Z}X \rightarrow \, ^{A-4}_{Z-2}Y + \, ^{4}_{2}He$




The energies of alpha particles emitted are lower than expected. What is expected is that the energy would be higher than the energy required (binding energy) to take out 2 neutrons and 2 protons out of the nucleus. This is explained by quantum tunneling

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5. Describe qualitatively the distinction between the excitation and the ionization of an atom.

The excitation of an atom is the action of moving an electron from one level to a higher one.

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The ionization of an atom is the action of taking out one electron out of the atomic orbitals and thus making ~~him~~ it a free electron.

6. Explain the difference between the electronic stopping power and the nuclear stopping power for alpha particles. For each one of the two terms, describe briefly the elastic or inelastic processes involved.

Stopping power: $S = -\frac{dE}{ds}$ (lost energy per distance)

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⊛ The electronic stopping power is considered with the energy lost by the alpha particle from interacting with electrons. This inelastic process is when energy is given to the electron to change its energy level or to be liberated (see ex 5). The elastic process is the deviation of the alpha particle (less likely).

⊛ The nuclear stopping power is considered from interaction with nucleus. It is ~~inelastic~~ energy is given to the nucleus and excites it. ~~If inelastic no energy is given to the nucleus.~~

7. After a photoelectric absorption has taken place, the target atom has been left with a vacancy in its innermost shell, the K shell. Describe qualitatively the relaxation process that follows and the possible types of emitted radiation. In particular, justify if this radiation will have a continuous or discrete spectrum.

In a photoelectric absorption, a photon hits a target nucleus and liberates one electron. It leaves then the nucleus with a vacancy (in this case we consider the K shell).

Then, a relaxation process happens when an electron of higher energy level than the vacancy goes down to fill the vacancy. However, there is an energy liberated that can have 2 options. The first one is liberation a photon (fluorescence). The second one can be the Auger effect where an electron is given enough energy to be liberated to a free state. ⊛

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⊛ Auger is possible for energies higher than the ionisation energy. So it might have a discrete spectrum. Fluorescence can happen with ~~specific~~ energies too because of the energy level. So discrete spectrum too.

8. In a photon field, write the equation that relates the absorbed dose rate at a certain point in space and the photon spectral flux density at that point. What is the name of the coefficient appearing in this formula? Explain whether or not this coefficient depends on: the material composition at the considered point; the material mass density; the photon energy; the photon direction of flight.

$$\boxed{\frac{dD}{dt} = \int E\,dE\,\varphi(E)\left(\frac{\mu_{en}}{\rho}\right)}$$

→ mass energy absorption coefficient: tabulated

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⊛ does depend on material composition at considered point

⊛ doesn't depend on material mass density

⊛ does depend on photon energy

⊛ doesn't depend on photon direction of flight