22.101 Applied Nuclear Physics
Fall 2006

QUIZ No. 3 (closed book) **December 13, 2006**

Problem 1 (25%)

Consider elastic scattering of neutron of energy E (LCS) by a stationary nucleus of mass A = M/n. Suppose the angular distribution of scattering per unit solid angle (CMCS), $P(\underline{\Omega}_c)$, is a constant A, for $0 \le \theta_c \le \pi/2$, and zero otherwise.

(a) Find the constant A.

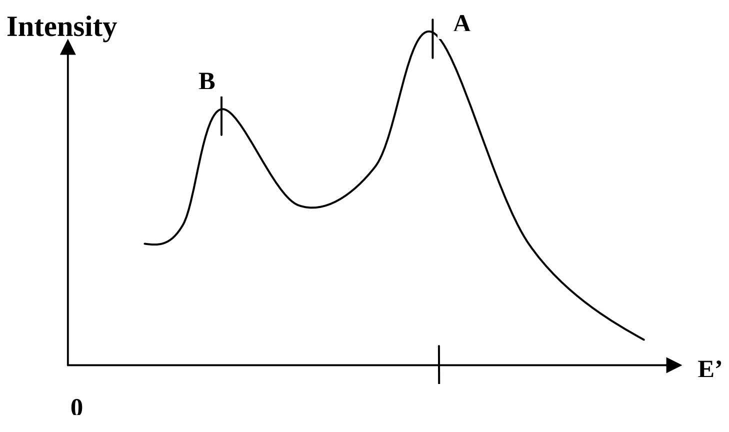
(b) Find the corresponding scattering probability $F(E \to E')$.

(c) Sketch your result and compare it with the result where $P(\underline{\Omega}_c)$ is spherically symmetric.

(d) Examine the energy range of the scattered neutron given by (b), compare with the range for spherically symmetric scattering, and comment on this comparison.

Problem 2 (25%).

You are given a sketch of the energy distribution of neutrons scattered at thermal energy E by atoms in a crystal at a certain temperature T and a scattering angle θ.



(a) What is the underlying process giving rise to peak A? Peak B? For each peak, how do you expect the intensity to vary with T and with θ (explain briefly)?

(b) Suppose now you are told that the energy distribution of photons scattered at arbitrary energy E by free electrons at a fixed scattering angle is also **given qualitatively by the sketch**. What processes are responsible for the two peaks in this case? What do you expect when the photon E is large or small compared to the electron rest mass energy? Would you expect the position of peak B to vary with the scattering angle? Explain.

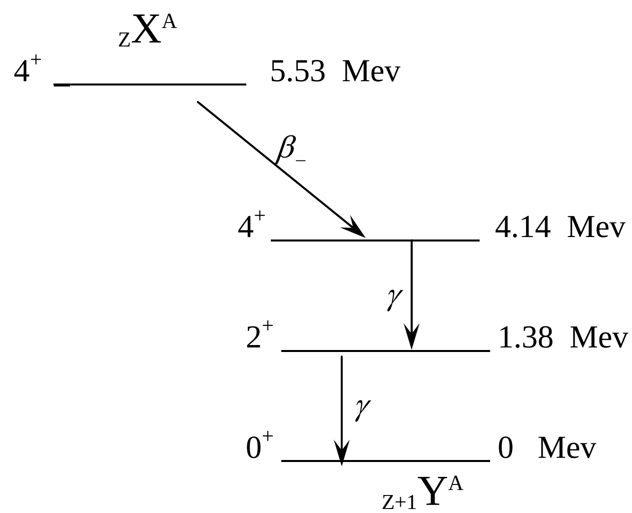
Problem 3 (25%)

Radioactive nucleus ${}_Z X^A$ is known to undergo β_- decay to ${}_{Z+1}Y^A$ (see the energy level diagram). In a measurement one finds a distribution of electrons, but in addition two groups of positrons with distinct end-point energies are observed.

(a) What could be the process giving rise to the positrons?

(b) What are the expected end-point energies of the two positron groups?

(c) What are the decay modes for the indicated transitions?



Problem 4 (25%) Answer each question briefly and concisely.

(a) Sketch the "edge" behavior in three cases: thermal neutron scattering cross section, gamma attenuation coefficient, and energy distribution of Compton electrons. Discuss the corresponding process in each case.

(b) Sketch the Klein-Nishina cross section for several values of $\hbar\omega / m_e c^2$ and explain all significant features or limiting behavior.

(c) Define Compton absorption cross section. Give a sketch of its variation with energy as seen in the mass attenuation coefficient along with an explanation of how this variation comes about.

(d) Compare the similarities and differences in the selection rules for β and γ decays.

(e) Sketch the cross section for elastic neutron scattering, showing the contributions from potential scattering, resonance scattering, and interference effects. Draw the energy level diagram for resonance scattering.