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NE 101
First Midterm
Closed Book

1. (16 points) A nucleus with decay constant λ is created at $t = 0$.
   a. What is the probability that it has decayed by the time $t = 3t_{1/2}$?
   b. What is the probability that it has not decayed at a time equal to 3 times the mean lifetime of the nuclide ?

2. (24 points) The semiempirical mass formula can be written in the form

$$M(Z,A) = ZM_H + (A-Z)m_n - a_v A + a_s A^{2/3} + a_c \frac{Z^2}{A^{1/3}} + a_{asym}\frac{(A-2Z)^2}{A} + \Delta .$$

   a. If the pairing energy has the magnitude δ, rewrite the equation explicitly for an odd, odd nucleus.
   b. In the limit of a very, very large nucleus with arbitrary (Z,A), what term or terms can be neglected to a good approximation? For credit you must provide an explanation for your answer.
   c. If the fundamental building block of nuclei were α particles instead of neutrons and protons, what term or terms would be removed from the mass formula?

3. (20 points)
   a. Estimate the energy release in the symmetric fission of $^{208}_{82}Pb$ neglecting all factors other than changes in the stored Coulomb energy. A numerical result is required for more than 25% credit for this part. Remember that in the classical limit, the stored Coulomb energy in a uniformly-charged sphere of radius r is $E_C = \frac{3}{5}\frac{q^2}{r}$ in Gaussian units.
   b. Assuming that the estimation of the stored Coulomb energy from part a to be exact, do you expect this result to correctly represent, overestimate or underestimate the energy release in fission of ^{208}Pb if it took place by symmetric fission ? You must provide a physical argument for credit.

2.818 fm
$E_C = \frac{3}{5}\frac{Z^2e^2}{m_ec^2} \cdot m_ec^2$

4. (14 points) The mass excesses (in keV) for the neutron and the atoms ^{1}H, ^{7}Li and ^{7}Be are 8071.32, 7288.97, 14907.67, and 15769.49, respectively. Calculate the Q value for the reaction $p + {}^7_3Li \rightarrow n + {}^7_4Be$.

$m_p = 938.272$
$m_n = 939.566$
$u = 931.494$

5. (10 points) Derive an expression for the Q value for positron decay of the nuclide M(Z,A) in terms of atomic masses.

6. (16 points) ^{64}Cu decays by both β^+/EC and β^- emission with the intensity ratio $I_{(\beta+/EC)} / I_{\beta-}$ = 1.564. The experimental half life of 64Cu is 12.70 h.

a. If you have a radiation detector that can only see β^- particles, what would be the half life that you would measure for ^{64}Cu ?

b. What would be the half of ^{64}Cu if it decayed only by β^+/EC ?