

# PHYS 316 Homework 9

Due: 31 March 2008

**Problem 1.** Das & Ferbel 3.5.

**Problem 2.** Das & Ferbel 4.1.

**Problem 3.** Das & Ferbel 4.6.

**Problem 4.** Calculate the expected half-lives of the Th isotopes listed in the table at the right. Compare the calculated values to the measured values provided in the table.

$A$	$Q$ (MeV)	$t_{1/2}$ (s)
220	8.95	$10^{-5}$
222	8.13	$2.8 \times 10^{-3}$
224	7.31	1.04
226	6.45	1854
228	5.52	$6.0 \times 10^7$
230	4.77	$2.5 \times 10^{12}$
232	4.08	$4.4 \times 10^{17}$

**Problem 5.** Each of the following nuclei emits a photon of the energy given when it decays from an excited state to its ground state. For each of these cases calculate the recoil energy of the nucleus and comment on how it compares to the experimental uncertainty.

(i)  $^{51}\text{V}$ ,  $E_\gamma = 320.08419 \pm 0.00042$  keV

(ii)  $^{110}\text{Cd}$ ,  $E_\gamma = 1475.786 \pm 0.005$  keV

(iii)  $^{22}\text{Ne}$ ,  $E_\gamma = 1274.545 \pm 0.017$  keV

(iv)  $^{56}\text{Fe}$ ,  $E_\gamma = 3451.152 \pm 0.047$  keV

**Problem 6.** When  $^{198}\text{Au}$  decays into  $^{198}\text{Hg}$  the mercury nucleus decays by emitting photons. Three photon energies are measured  $E_{\gamma_1} = 411.80441 \pm 0.00015$  keV,  $E_{\gamma_2} = 675.88743 \pm 0.00069$  keV, and  $E_{\gamma_3} = 1087.69033 \pm 0.00074$  keV. These results suggest that the  $^{198}\text{Hg}$  nucleus can be described by two excited states,  $E_1$  and  $E_2$ , with the three photons corresponding to the transitions,  $E_1 \rightarrow E_0$ ,  $E_2 \rightarrow E_1$ , and  $E_2 \rightarrow E_0$ . If this is correct then we would expect  $E_{\gamma_1} + E_{\gamma_2} = E_{\gamma_3}$ .

(i) Show that for the values given above that  $E_{\gamma_3}$  does **not** agree with our expectation to within the experimental error bars.

(ii) Show that if we include the nuclear recoil we do get good agreement.