Final Exam

Due Date: Friday December 11, 2015, 5PM in the Instructor's mailbox

Proton Decay

There are theoretical reasons to believe that the decay

$$p \to e^+ + \pi^0$$

might occur. The decay has never been observed, and this has been turned into an experimental limit on the proton lifetime:

$$\tau_p = \frac{\hbar}{\Gamma} > 1.6 \times 10^{33} \text{ yr.}$$

The most general matrix element for the process, compatible with Lorentz invariance and momentum conservation, has the form:

$$\mathcal{M} = \bar{u}(\vec{p}_{e^+})\ T\ u(\vec{p}_p), \quad \text{with} \ \ T = A + B\gamma^5.$$

where A and B are constant.
(i) Which constraints would parity conservation impose on the constants A and B?
(ii) Calculate the decay width for the proton decay process as a function of A and B.
(iii) Calculate the constraints on A and B from the lower limit on the proton lifetime.
(iv) The π^0 is not directly observed, since it decays immediately into two photons. Knowing that the π^0 has spin zero, calculate the distribution of the angle the photons form with the direction of motion of the positron in the final state.