Take Home Exam III
Fusion

1)a) We have discussed several types of fusion in class. Fusion inside stars, fusion in a hot plasma and fusion due to particle collisions. One process we didn't mention is called muon catalyzed fusion. Briefly, an isotope of hydrogen has its electron replaced by a muon. This allows other isotopes of hydrogen to approach this muonic isotope much more closely.

Estimate the relative separation of the hydrogen atoms in an H_2 molecule and in an H_2 molecule where one of the hydrogen atoms has acquired a muon. (You can reason this through or look at the beginning of chapter 9 in Krane for a starting place. Note: do not try to solve this exactly, reason through in an analogy to the hydrogen molecule to get an estimate.)(10 pts)

Now, calculate the temperature needed to bring 2 protons this close together. I.e. Treat your estimate above as the "turning point", and work backwards to find the temperature.(10 pts)

Ok, lets assume that this is a good temperature estimate for all the isotopes of hydrogen. Look at the graph in the lecture on fusion and pick off the highest value of $< v\sigma >$ you can find for the temperature you calculated. Now suppose there is a beaker with equal mixtures of the 2 isotopes you chose and half of the mixture is muonic. What fusion rate/volume do you expect? (I would look up the density of the liquid forms to perform the calculation)(10 pts)

Actually, a better number to get from this is the mean lifetime of a muonic atom in this soup. Relate the rate of reaction/volume to the decay constant times a density. Estimate the mean lifetime. Consider the lifetime of the muon. Estimate the number of fusion reactions a single muon can participate in before it disappears.(15 pts)