Exercise 1

Exercises with * compulsory for pass. Those with ** and *** for extra points.

1. Do a 'back of the envelope' derivation of the Chandrasekhar mass and the mass – radius relation for a white dwarf. *

2. Estimate how much energy per nucleon (in MeV) and in ergs/g one gains in fusion of $^{12}\text{C}$ all the way up to $^{56}\text{Fe}$. The same, but for photodissociation of $^{56}\text{Fe}$ into $\alpha$ particles. *
   Here is a useful link:

3. Show the steps leading up to the equation of NSE, (Eq. 1.66) *

4. Discuss the similarity and differences in the evolution of stars in the interval $10^{-60} \text{M}_\odot$, from the main sequence until core collapse.
   Here are some useful references, in addition to the lecture notes:
   Woosley, S. E., Heger, A. and Weaver, T. A., ”The evolution and explosion of massive stars”, Reviews of Modern Physics, 2002, 74, 1015
   Here are some questions you are expected to address:
   (a) What are the durations in the different burning stages? *
   (b) Why do they decrease so fast? *
   (c) At what positions in the HR diagram do the various burning stages start? *
   (d) When do the neutrinos dominate the energy losses? *
(e) What is the total radius of the star and the He, O and Fe core before explosion? *

(f) What are the main differences in the nucleosynthesis between different masses? *

(g) Describe the role of convection and why does it occur? **

(h) What is the effect of mass loss for the different masses? **

(i) What is the role of rotation? **

(j) What are the surface abundances before explosion? **

(k) What is the difference between a 10 and a 15 M⊙ star? **

(l) What is the difference between the calculations in Limongi et al, Hirschi et and WHW? ***