Problems 2 "Stars from birth to death" - Lectures V-IX

1) Let us assume that the total nuclear energy produced by the central region of a star of 1 $M_\odot$ is due to the reaction: $^{12}C + p \rightarrow {}^{13}C$

Calculate its approximate lifetime assuming that it burns 10% of the total mass of ^{12}C contained in this star and that the stellar luminosity is 1 $L_\odot$.

Additional information:

mass of ^{13}C= 13.003355 mu
proton mass $\approx m_H$= 1.0081 mu
Mass fraction of ^{12}C in the star: 3×10^{-3}
$L_\odot = 4 \times 10^{26}$ W
$M_\odot = 2 \times 10^{30}$ kg

2) - Explain how some chemical elements produced in the central region of a star are transported toward its surface. Give examples of such elements.

- Draw a Kippenhahn diagram (interior mass versus time) for a 5 $M_\odot$

- What is the maximum stellar mass able to ignite H fusion reactions?

- What is the maximum stellar mass able to ignite C fusion reactions?

3) What are the typical temperatures for the destruction of respectively deuterium, lithium and beryllium through proton capture in stars?
- What is the minimum temperature at which CNO cycle provides the dominant nuclear energy generation compared to the energy produced by the PP chain?
- Why stars with masses below ~ 2 $M_\odot$ do not experience a central helium burning phase?

4) - Write the polytropic relation between the pressure and the density as a function of the polytropic index n.
- What is the significance of a polytropic index n=3/2?
- Give example of astrophysical objects which can be described by a polytrope of index n=3/2

5) Show that the change of density $d\rho$ in a layer (r, ρ, P) after expansion dr is given by $d\rho/\rho = -3\, dr/r$ and the change of pressure dP is given by $dP/P = -4\, dr/r$