Exam Stellar Structure and Evolution

1 February 2018, 09:00–12:00

Name & Student Number:

This part of the exam is written with oral clarification if you choose so and counts for 12 points. The MESA lab work + its obliged oral exam counts for 8 points.

1. Consider a ZAMS star born with $15\,\mathrm{M}_\odot$ and an initial chemical composition of $(X, Y) = (0.74, 0.24)$. You find its fractional mass, pressure, density, temperature, and fractional luminosity as a function of fractional radius r/R in the figures attached.

   (a) Estimate the radiative temperature gradient inside this star at position $r/R = 0.3$ assuming that the Rosseland mean opacity is well approximated by the opacity due to Thomson scattering of electrons, $\kappa_\mathrm{e} \simeq 0.3\,\mathrm{cm}^2/\mathrm{g}$.

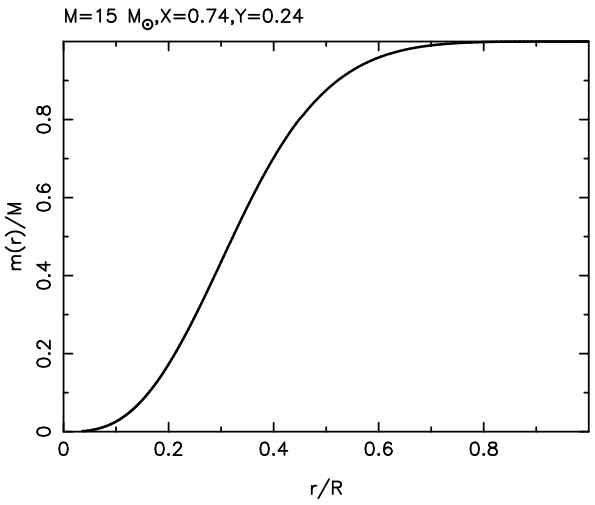
   (b) Estimate the adiabatic temperature gradient inside this star at position $r/R = 0.3$.

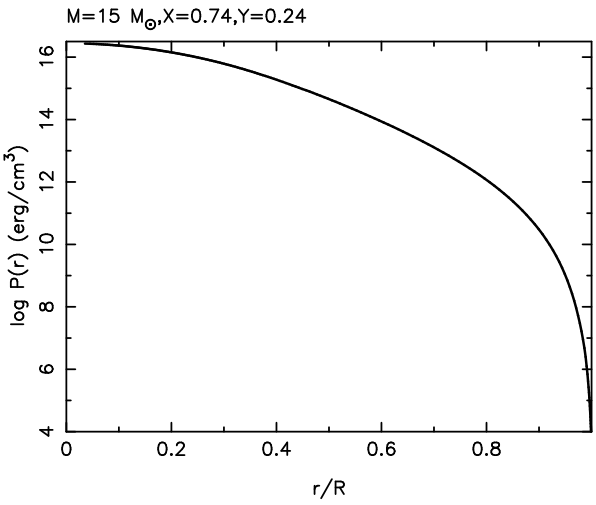
   (c) Does the energy transport at $r/R = 0.3$ happen convectively or by radiative diffusion of photons? Explain your answer.

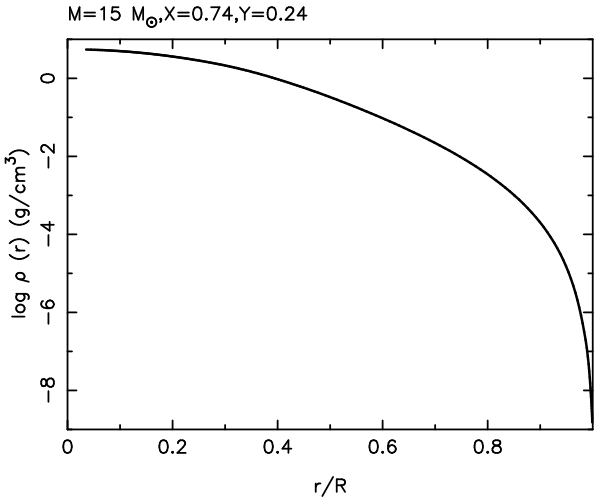
   (6 points, maximally 1 page)

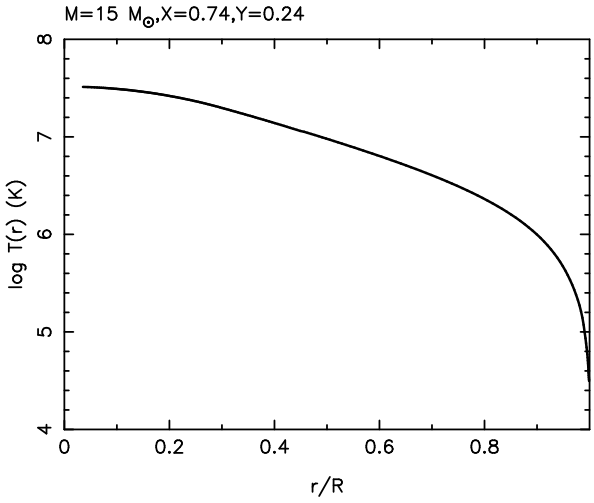
2. During which nuclear burning stage will this star undergo its first dredge up? Explain the physical meaning of this phenomenon. Can we observe the results of this dredge up? If so, how? If not, why not? (2 points, maximally 1/2 page)

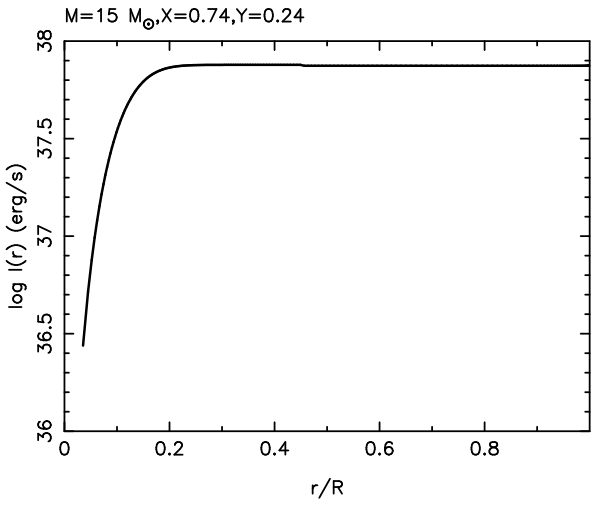
3. Describe the evolution of this star, starting from the end of the core helium burning stage. In particular, discuss how this star will end its life? Estimate how old it will be at the end of its life and assess how accurate your age estimate is. What is the remnant product? (4 points, maximally 1 page)


M=15 M$_\odot$,X=0.74,Y=0.24
m(r)/M
r/R


M=15 M$_\odot$,X=0.74,Y=0.24
log P(r) (erg/cm^3)
r/R


M=15 M$_\odot$,X=0.74,Y=0.24
log ρ (r) (g/cm^3)
r/R


M=15 M$_\odot$,X=0.74,Y=0.24
log T(r) (K)
r/R


M=15 M$_\odot$,X=0.74,Y=0.24
log l(r) (erg/s)
r/R