1. Solar Neutrinos:
The flux of energetic neutrinos from $^8\text{B}$ decays in branch III of the proton-proton chain is very dependent on the central temperature of the Sun. Confirm this by showing that the rate of the reaction producing $^8\text{B}$,
\[ p + ^7\text{Be} \rightarrow ^8\text{B} + \gamma, \]
is approximately proportional to $T^{14}$, when the temperature $T$ is near to $1.5 \times 10^7$ K. In fact, the local production rate of neutrinos from $^8\text{B}$ decay is proportional to $T^{24}$ when the temperature dependence of the reactions leading to $^7\text{Be}$ formation is taken into account; see Bahcall (1989, *Neutrino Astrophysics*, Cambridge University Press).

2. Helium Burning:
Calculate the power per kilogram produced by helium burning in pure helium when the density is $10^8$ kg m$^{-3}$ and the temperature is $10^8$ K. By how much would this power change if the excitation energy of the $0^+$ state of carbon-12 were 7.66 MeV instead of 7.65 MeV?

3. Origin of Helium (Ph 541 students only):
Estimate what fraction of our Galaxy’s mass has been converted from H to He in stars since its formation (say $1.0 \times 10^{10}$ years ago, the approximate age of the Galactic disk), assuming that the average star has a mass-to-luminosity ratio ($\mathcal{M}/\mathcal{L}$) ten times that of the Sun. How does this fraction compare to the observed mass fraction of helium in the Sun, which is about 0.25?