5.1 Bresolin et al. (2004, ApJ 615, 228) analyze the line intensities of H II regions in the spiral galaxy M51. Using the line intensities in their Table 1, reproduce their analysis for CCM 72.
(a) What is the electron density?
(b) From the [N II] line ratio, derive the electron temperature $T(\mathrm{N}^{+})$.
(c) Derive the abundance ratios $\mathrm{O}^{+}/\mathrm{H}^{+}$, $\mathrm{O}^{+2}/\mathrm{H}^{+}$, & $\mathrm{Ne}^{+2}/\mathrm{H}^{+}$. Estimate $T(\mathrm{O}^{+2})$ from equation (2) of Bresolin et al. and use this value also for Ne^{+2}. Compare your results with Table 4 in the article.
(d) Derive the total oxygen abundance $N(O)/N(H)$ and check against Table 5 in the article. Also compare your result with the solar system abundances given in part 1 of *Hazy*, the documentation for CLOUDY (Ferland 2006).
(e) Compare your value of $\mathrm{Ne}^{+2}/\mathrm{O}^{+2}$ with the solar system abundances. If the Ne/O ratio is universal, does it appear that Ne^{+2} and O^{+2} occupy the same volume in the nebula?

5.2 Using CLOUDY, run a model planetary nebula with a hydrogen density $10^{3.3}$ cm^{-3} and starting radius 10^{17} cm ionized by a 70,000 K black body with a luminosity of 10^{37} erg s^{-1}. Use the default solar system abundances in CLOUDY. Make sure your calculation reaches the Strömgren sphere.
(a) Verify that the total luminosity of Hβ in the model output is what is expected for the value of $Q(\mathrm{H}^{0})$ given by the model output.
(b) Treating the model intensities of $\lambda\lambda 5007, 4959$ and $\lambda 4363$ as data, derive the temperaure T(O III). Compare with the value of $< T(\mathrm{O}^{+2} >$, weighted by electron density and volume, given in the CLOUDY output. Ignore collisional de-excitation.
(c) Use your derived T(O III) and the model line intensities to calculate the $\mathrm{O}^{++}/\mathrm{H}^{+}$ abundance ratio. Compare with the quantity $[< X(\mathrm{O}^{+2}) > / < X(\mathrm{H}^{+}) >][N(\mathrm{O})/N(\mathrm{H})]$, taking the mean ionization fractions and oxygen abundance from the model.