1. 1 g of an electrically neutral astrophysical plasma contains 700 mg $^1$H, 110 mg $^4$He, 70.0 mg $^{14}$C, and 120 mg $^{22}$Ne. The mass density is 75.0 g/cm$^3$ and remains constant throughout. Feel free to submit a printout of an excel spreadsheet. However, you need to explain clearly how all the calculations are done (equations). It is not sufficient to just give numbers.

   a. [2pts] Characterize the composition using the different abundance measures used in nuclear astrophysics (you only have to worry about nuclei). In a table that gives for each constituent isotope:
      i. mass fraction
      ii. abundance ("mole fraction")
      iii. number fraction
      iv. number density
      v. abundance using the notation and units used by Grevesse & Sauval Space Sci Rev 85 (1998) 161, Table1.

   b. [2pt] Calculate mean molecular weight, Ye and electron number density for the mix.

2. For the same astrophysical plasma described in problem 1, now assume that $^{22}$Ne and $^4$He undergo a nuclear reaction. In this reaction, each $^{22}$Ne nucleus fuses with a $^4$He nucleus, and in the process neutron is emitted (a $^{22}$Ne($^4$He,n) reaction). Assume that this reaction occurs until all possible $^4$He and $^{22}$Ne pairs have been converted into reaction products. Answer all the questions from Problem 1 for the new resulting composition (include all reaction products).

3. What is the advantage of using abundance (mole fraction) to characterize a composition? (compare abundances before and after the reaction occurred)

4. Now assume that for the composition obtained in problem 2, all $^{14}$C beta decays into $^{14}$N (a neutrino and an electron are emitted in the process). Calculate the $Y_e$ of the new composition.

5. Compare the initial $Y_e$ in Problem 1 with the $Y_e$ obtained in Problem 2 and 3. In general, which reactions do change $Y_e$ and which don't and why?