# Evaluation guidelines for Project 2, AST3220, 2022

a) Max 5p: Derives one of eq. (10) or (11) (3p)

+ derives the other, or argues that it is the same, but with $n \rightleftharpoons p$ (2p)

Bonus Q) Max 5p: Makes correct estimate of $\rho_b$ at $T \sim 10^9$ K (2p)

+ compares to Sun (1p)

+ correct estimate of $\rho_b/\rho_\nu$ (2p)

b) Max 5p: Argues it is because entropy is conserve before and after $e^- - e^+$ annihilation (1p)

+ counts relativistic degrees of freedom to get something like

$$(aT)_{aftn} = (aT_\nu)_{before/after} = \left(\frac{11}{4}\right)^{1/3} (aT)_{before},$$

hence $T_\nu = \left(\frac{4}{11}\right)^{1/3} T$ (2p)

+ correctly states that using this relation throughout BBN assumes $e^- - e^+$ annihilation was complete before our BBN simulations start. (2p)

c) Max 5p: Uses $\rho_\gamma$ and $\rho_\nu$ (1p)

+ with correct number of relativistic degrees of freedom (1p)

+ and inserts $T_\nu = \left(\frac{4}{11}\right)^{1/3} T$ (1p)

+ divides by $\rho_{c0} = \frac{3H_0^2}{8\pi G}$ to get $\Omega_{r0}$. (2p)

d) Max 5p: Finds $a(t)$ (2p)

+ finds $t(T)$ (2p)

+ computes $t(T)$ for the given $T$'s correctly (1p)

e) Max 5p: Finds at least $Y_n / Y_p$ or something equivalent (1p)

+ shows that $Y_n + Y_p = 1$ (2p)

+ shows eq. for $Y_n$ (2p)

f) Max 10p: 5p for code

+ 3p for $Y_n$ and $Y_p$ from simulation in plot

+ 2p for $Y_n$ and $Y_p$ at equilibrium in plot

g) Max 5p: Get the "decay" terms correctly (2p)

+ get the "reaction" terms correctly (2p)

+ get the final eq. on correct form. (1p)

h) Max 10p: 2p for code
+ 4p for plot
+ 4p for the description of what is happening in the plot.

i) Max 20p: 10p for code
+ 10p for plot

j) Max 15p: Computes $Y_i$ and $\chi^2$ as functions of $\Omega_{b0}$ (5p)
+ reproduces plot (5p)
+ states that the best-fit of $\Omega_{b0}$ shows that a large portion of matter cannot be baryonic, but instead some unknown form of matter (5p)

k) Max 15p: Computes $Y_i$ and $\chi^2$ as functions of $N_{eff}$ (5p)

+ reproduces plot (5p)

+ states that the best-fit of $N_{eff}$ agrees with there being 3 types of known neutrinos. (5p)

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The max is 100p + 5p

We will not substract points for minor errors in the $Y_i$ plots, in particular for $Li^7$.

Deductables:

- Breach of anonimity: 5p
- Figures without labels, units, otherwise messig: Up to 5p
- Annoying number of grammatical errors: Up to 5p
- Code that won't run/compile: Up to 30p
- Messy, uncommented code: Up to 10p