Assignment X

1. $4H \to {}^4He$ + energy (in positrons, neutrinos and gamma rays)

$E = (\Delta m)c^2 = (m_{4H} - m_{4He})c^2$ = energy in positrons, etc.
$= (4 \cdot 1.6737 \cdot 10^{-27}\,kg - 6.6447 \cdot 10^{-27}\,kg) \cdot (3 \cdot 10^8\,m/s)^2$
$= 4.51 \cdot 10^{-12}\,J$ (28 MeV)

The Sun is 3/4 H by mass, so it has $0.75\,M_\odot/m_H$
$= 0.75 \cdot 1.9891 \cdot 10^{30}\,kg / 1.6737 \cdot 10^{-27}\,kg = 8.91 \cdot 10^{56}$ H atoms

It takes 4H nuclei for one reaction, so $2.22 \cdot 10^{56}$ rxn.
so $2.22 \cdot 10^{56}$ rxn $\cdot$ $4.51 \cdot 10^{-12}$ J/rxn
$= 1.00 \cdot 10^{45}\,J$
This is the total energy emitted by the Sun during its life

$$\frac{1.00 \cdot 10^{48}\,J}{3.84 \cdot 10^{26}\,W} = \underline{\underline{2.62 \cdot 10^{18}\,s}} = \underline{\underline{82.9\,Gyr}}$$

The true lifetime of the sun is ~10 Gyr, because it doesn't burn all its hydrogen.

2. $T \propto 1/a \propto 1 + z$ (since $1 + z(t) = a_0/a(t)$, so $1 + z(t) \propto \frac{1}{a(t)}$)

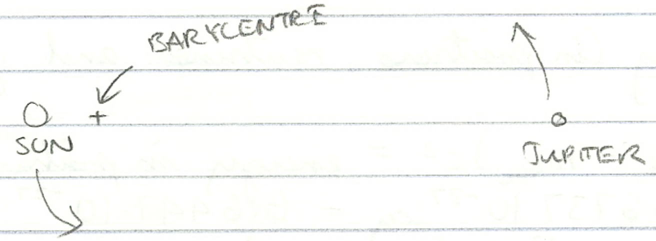
$$\frac{T_{SF}}{T_{CMB}} = \frac{1 + z_{SF}}{1 + z_{CMB}}$$

$$z_{SF} = \left(\frac{T_{SF}}{T_{CMB}}\right)(1 + z_{CMB}) - 1$$

$$= \frac{100k}{3000k}(1 + 1100) - 1 = \underline{\underline{35.7}}$$

This is higher than the age redshift of HD1523-0901

3.



If the CM is fixed in space, then $V_{CM} = 0$

$$V_{CM} = \frac{M_\odot V_\odot + M_J V_J}{M_{total}} = 0$$

$$M_\odot V_\odot = -M_J V_J$$

$$V_\odot = -\frac{M_J}{M_\odot} V_J \rightarrow |V_\odot| = \text{magnitude of vel} = \frac{M_J}{M_\odot} V_J$$

$$|V_\odot| \approx \frac{1}{1000} \cdot 13 \text{ km/s} = 0.013 \text{ km/s} = 13 \text{ m/s}$$

$$\frac{\Delta\lambda}{\lambda} = \frac{v}{c} = \frac{13 \text{ m/s}}{3 \cdot 10^8 \text{ m/s}} = \underline{4.33 \cdot 10^{-8}}$$

We can actually do better than this with today's telescopes.