Helium

\[ \text{Helium} = 2 + 10 \quad \text{and Helium is} \quad \frac{1}{4} \text{this} \]

so \( M_{\text{Helium}} = 5 \times 10 \)  

\[ m = 4 \times \frac{\text{newtons}}{\text{meter}^2} = 6.8 \times 10^{-24} \text{g} \]

so \( \# \text{Helium nuclei} = 7.35 \times 10^{-55} \) in 5.4s

Luminosity \( \times 5.11 \) is \( 3.8 \times 10^{-22} \)  

\( = \# \text{Helium formed} \times \text{sec} \times 4.23 \times 10^{-5} \text{e}^{-25} \)

so \( \# \text{Helium formed/ sec} = 8 \times 10^{-37} \)

in 4.56 billion years \( [1.4 \times 10^{17} \text{ sec}] \) we have

\( 1.26 \times 10^{55} \) nuclei

\( \# \text{formed} = 15 \quad 0.17 = \frac{1}{5.8} \text{ of } M_{\text{Helium in 5.4s}} \)
c) Lenders have checked down on
- \( m = \frac{1}{2} \) m
- \( \rho = 2 \text{ g/cm}^3 \)
- \( T = \text{in, m} = \text{in of system} \)
- an asteroid

b) Meteors are made of some rocky/ metallic substance [different ones are different]. Let's take 1 cubic cm density to be \( \rho \) cm\(^3\). Then the meteor's mass is

\[ M = \frac{4}{3} \pi r^3 \rho = 1.06 \times 10^6 \text{ g/m}^3 \]

\[ \frac{1}{2} \text{ meter} = 52 \text{ cm} \]

d) Released energy = \( \frac{1}{2} M c^2 \) since \( E = mc^2 \)

\[ \text{energy of meteor} = 5 \text{ cm}^2 \]
\[ E_{\text{released}} = 1.91 \times 10^{27} \text{ ergs} \]

\[ = 46,000 \text{ megatons} \]

d) since meteors are flying about randomly:

\[ \text{the rate of hitting a bull's eye probability is proportional to its surface area} \]

\[ \frac{\text{Rate hitting Sun}}{\text{Rate hitting Earth}} = \left( \frac{R_{\text{Sun}}}{R_{\text{Earth}}} \right)^2 \]

\[ = \left( \frac{6.96 \times 10^6 \text{ cm}}{6.38 \times 10^8 \text{ cm}} \right)^2 = 1.19 \times 10^4 \]

so \[ 1.19 \times 10^4 \text{ of these meteors hit the Sun each hour} \]
(f) Each meteor releases $1.91 \times 10^{27}$ ergs so the rate of energy release is

$$1.17 \times 10^4 \text{ meters/hour} = 4.28 \times 10^7 \text{ meters per second}$$

So,

$$\left[4.28 \times 10^7\right] \times \left[1.91 \times 10^{27}\right]$$

$$= 8.18 \times 10^{34} \text{ ergs/second}$$

This is more than the Sun's luminosity, which is $3.8 \times 10^{33} \text{ ergs/second}$, so we would notice it.
Moment of the Big Bang

From the Friedmann equation

\[ \left( \frac{R}{R_0} \right)^2 = H^2 = \frac{8\pi G \rho(t)}{3 R^3(t)} - \frac{k}{R^2} \]

Factor out \( \frac{1}{R^3} \) to get

\[ H^2 = \frac{8\pi G \rho(t)}{3 R(t)} - \frac{k}{R(t)} \]

Where \( k = \text{const} \) goes to zero

So \( H^2 \) is positive \( \approx \text{time} \) \( \geq \text{big bang} \)

\( \sqrt{R^3} \), which goes to zero, goes positive \( \infty \)

Another way: factor out \( R^2 \)

\[ H^2 = \frac{1}{R^2(t)} \left( \frac{8\pi G \rho(t)}{3 R(t)} - \frac{k}{R(t)} \right) \]

\( \rho \to \text{const} \)

\( R \to \infty \text{ and } k \to \text{big bang} \)

\( H \) goes to plus \( \infty \)
For $h = 0$, \[ R(t) = \left[ \frac{2}{3} t \right]^{2/3} \] and \[ N = R(t) + R(t + \epsilon) \]

\[ R = \left[ \frac{2}{3} t \right]^{2/3} t^{-1/3} \] which goes to $\infty$ as $t \to 0$. Thus $N$ goes to $\infty$ as $t \to 0$.

For any other $h$, use the fact that we proved in class that, no matter what $h$ is, as $R \to \infty$, the $h = 0$ solution approach the $h = 0$ solution.