$\boxed{1}$ (a)

$$\frac{\Lambda}{n_H^2} \simeq 5\times10^{-25}\ \frac{\text{erg cm}^3}{\text{s}}$$

$$\Lambda = \left(5\times10^{-25}\ \frac{\text{erg cm}^3}{\text{s}}\right)\left(0.5\ \text{cm}^{-3}\right)^2$$

$$\Lambda = 1.25\times10^{-25}\ \frac{\text{erg}}{\text{s cm}^3}$$

$$\text{VOLUME OF CLOUD} = \frac{4}{3}\pi\,(10\,\text{pc})^3\left(\frac{3.1\times10^{18}\,\text{cm}}{\text{pc}}\right)^3$$

$$= 1.25\times10^{59}\ \text{cm}^3$$

$$\text{COOLING RATE} = \left(1.25\times10^{-25}\ \frac{\text{erg}}{\text{s cm}^3}\right)\left(1.25\times10^{59}\ \text{cm}^3\right)$$

$$= 1.6\times10^{34}\ \frac{\text{erg}}{\text{s}} = 1.6\times10^{27}\ \frac{\text{J}}{\text{s}}$$

$$L_\odot = 3.8\times10^{26}\ \text{W} \rightarrow \text{SIMILAR!}$$

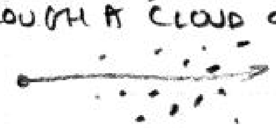
(b) @ A GIVEN TEMPERATURE, ELECTRONS WILL MOVE FASTER THAN OTHER MORE MASSIVE PARTICLES

$$\frac{3}{2}kT \simeq \frac{1}{2}mv^2$$

AS SUCH, THEY "SWEEP OUT" MORE SPACE AND COLLIDE MORE OFTEN.

THE NUMBER OF COLLISIONS IS THEREFORE VERY SENSITIVE TO THE NUMBER OF ELECTRONS. MORE COLLISIONS = MORE OPPORTUNITIES TO EXCITE ATOMS INTO STATES WHERE THEY CAN RADIATE ENERGY AWAY

(c) COLLISIONS MATTER; SEE ABOVE. IMAGINE ONE PARTICLE MOVING THROUGH A CLOUD OF PARTICLES



THE RATE AT WHICH IT COLLIDES IS PROPORTIONAL TO THE DENSITY OF THE CLOUD; THAT'S ONE FACTOR. THE NUMBER OF PARTICLES MOVING TO COLLIDE GIVES YOU THE OTHER FACTOR.

2

(a) $d = vt$

$$t = \frac{d}{v} = \frac{120\ \text{mi}}{60\ \text{mi/h}} = 2\ \text{h}$$

(b)

$$\Delta v = at$$

$$(0 - 60\ \text{mph}) = \left(-20\ \frac{\text{mph}}{\text{s}}\right) t$$

$$\boxed{t = 3\ \text{s}}$$

(c)

$$\tau = \frac{\varrho}{\Lambda} \qquad \frac{\frac{\text{erg}}{\text{cm}^3}}{\frac{\text{erg}}{\text{cm}^3 \cdot \text{s}}} = \text{s} \Rightarrow \text{RIGHT UNITS}$$

3

(a)

$$\varrho = (2)\underbrace{\left(\frac{3}{2} kT\right)}_{\text{ENERGY PER PARTICLE}} \underbrace{n_H}_{\frac{\text{PARTICLES}}{\text{VOL}}} = \frac{\text{ENERGY}}{\text{VOL}}$$

EACH H-ATOM GIVES ONE PROTON & ONE ELECTRON → 2 PARTICLES (H WILL BE FULLY IONIZED @ $T = 10^7$ K)

$$\varrho = 2\left(\frac{3}{2}\right)\left(1.38 \times 10^{-16}\ \frac{\text{erg}}{\text{K}}\right)\left(10^7\ \text{K}\right)\left(1\ \text{cm}^{-3}\right)$$

$$\boxed{\varrho = 4.1 \times 10^{-9}\ \frac{\text{erg}}{\text{cm}^3}}$$

(b) $\frac{\Lambda}{n_H^2} \sim 2 \times 10^{-23}\ \frac{\text{erg cm}^3}{\text{s}}$ SO $\Lambda = 2 \times 10^{-23}\ \frac{\text{erg}}{\text{cm}^3\text{s}}$ FOR $n_H = 1\ \text{cm}^{-3}$

$$\tau = \frac{\varrho}{\Lambda} = \frac{4.1 \times 10^{-9}\ \frac{\text{erg}}{\text{cm}^3}}{2 \times 10^{-23}\ \frac{\text{erg}}{\text{cm}^3 \cdot \text{s}}} = 2 \times 10^{14}\ \text{s} = \boxed{6 \times 10^6\ \text{yr}}$$

3 (c) NUMBERS ARE ALL ~10 x TOO BIG

4 $n_H \sim 0.1\ cm^{-3}$

$T \sim 10^7 K$

$$\rho \sim 2\left(\frac{3}{2}kT\right)n_H$$

$$\sim 2\left(\frac{3}{2}\right)\left(1.38\times10^{-16}\frac{erg}{K}\right)\left(10^7 K\right)\left(0.1\ cm^{-3}\right)$$

$$\sim 4\times10^{-10}\ \frac{erg}{cm^3}$$

$$\Lambda \sim \left(2\times10^{-23}\ \frac{erg\ cm^3}{s}\right)\left(0.1\ cm^{-3}\right)^2$$

$$\sim 2\times10^{-25}\ \frac{erg}{cm^3\cdot s}$$

$$\tau = \frac{\rho}{\Lambda} = \frac{4\times10^{-10}\ \frac{erg}{cm^3}}{2\times10^{-25}\ \frac{erg}{cm^3\cdot s}} = 2\times10^{15} s$$

$$= 7\times10^7\ yr$$

(ABOUT 100 mil yrs)

5 (a) $F_{pix} = \frac{N_* L_{RG}}{4\pi d^2}$ # STARS IN ONE PIXEL

(b) $$\Delta F_{pix} = \Delta N_* \frac{L_{RG}}{4\pi d^2}$$

$$= \sqrt{N_*}\ \frac{L_{RG}}{4\pi d^2}$$

(c) $$\frac{\Delta F_{pix}}{F_{pix}} = \frac{\Delta N_*}{N_*} = \frac{\sqrt{N_*}}{N_*} = \frac{1}{\sqrt{N_*}} \Rightarrow N_* = \left(\frac{F_{pix}}{\Delta F_{pix}}\right)^2$$

$$F_{pix} = \frac{\left(\frac{F_{pix}}{\Delta F_{pix}}\right)^2 L_{RG}}{4\pi d^2}$$

$$\boxed{d = \sqrt{\frac{F_{pix}\, L_{RG}}{4\pi (\Delta F_{pix})^2}}}$$

CHECK UNITS

$$\sqrt{\frac{\left(\frac{erg}{cm^2\cdot s}\right)\left(\frac{erg}{s}\right)}{\left(\frac{erg}{cm^2\cdot s}\right)\left(\frac{erg}{cm^2\cdot s}\right)}} = s\ ✓$$