ISM HW #1

1) $M = 7 \times 10^9 M_\odot$

$R_{disk} = 15\,kpc$

$h = 200\,pc$

$mfp = \frac{1}{n\sigma}$

$n = \frac{N}{V} = \frac{7 \times 10^9 M_\odot / m_H}{\pi \cdot (15\,kpc)^2 \cdot 200\,pc} = \frac{8.37 \times 10^{66}}{4.15 \times 10^{66}\,cm^3}$

$= 2.00\,cm^{-3}$

$\sigma \approx \pi \cdot (1.529 \times 10^{-9}\,m)^2$ (Approx. real values for H_2 OM; this is Bohr rad.)

$= 8.79 \times 10^{-17}\,cm^2$

$mfp = \frac{1}{8.79 \times 10^{-17}\,cm^2 \cdot 2.00\,cm^{-3}} = 5.6 \times 10^{15}\,cm = 0.018\,pc$

b) $M_{clouds} = 0.3 \times 7 \times 10^9 M_\odot = 2.1 \times 10^9 M_\odot$

$M_{cloud} = n \cdot m_{H_2} \cdot V = 100\,cm^{-3} \cdot 3.35 \times 10^{-24}\,g \cdot 4/3 \cdot \pi \cdot (15\,pc)^3$

$= 1.39 \times 10^{38}\,g = 7.00 \times 10^4\,M_\odot$

$N = M_{clouds} / M_{cloud} = 3 \times 10^4$

Assume same density NaN mass per particle increases

$\mu = \frac{2 \cdot m_H + 2 \cdot m_{He} \cdot 0.1}{m_H} = 1.4$

So mass of cloud increases by 40%.

N decreases by 40%.

2) $\rho_{grain} = 2\ g\ cm^{-3}$

$a_{grain} = 0.1\ mm$

$m_{grain} = \rho_{grain} \cdot V_{grain} = 2\ g\ cm^{-3} \cdot \frac{4}{3}\pi (0.1\ mm)^3$

$= 8.4 \times 10^{-5}\ g$

Spacecraft sweeps through volume

$V = A \cdot v \cdot t$

$= A \cdot 26\ km/s \cdot 1\ hr$

$= A \cdot 9.4 \times 10^9\ cm$

For one particle per hour,

$n_{dust} = V = 9.4 \times 10^9\ cm \cdot A$

$\Rightarrow A = \frac{n_{dust}}{9.4 \times 10^9\ cm}$

Just need n_{dust}

$\rho_{dust} = 0.005\ \rho_{gas} = 0.005\ (\rho_H + \rho_{He})$

$\mu = \frac{m_H + m_{He} \cdot 0.1}{m_H} = 1.4$

$\rho_{dust} = 0.005\ (1.4\ \rho_H) = 0.005 \cdot 1.4 \cdot 0.22\ cm^{-3} \cdot m_H$

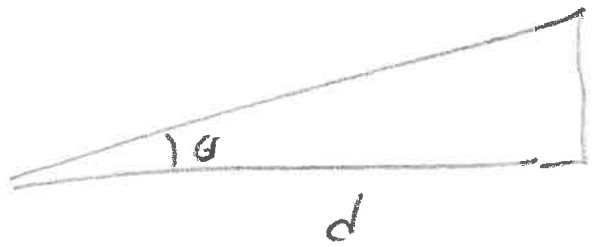
$\Rightarrow n_{dust} = \rho_{dust} / m_{grain} = 3.1 \times 10^{-3}\ cm^{-3}$

$\Rightarrow A = 347\ cm^2$

3) $P = nkT = 30\,cm^{-3} \cdot k \cdot 10^2 K = 4.14\ erg\ cm^{-3}$

All in equilibrium, so $n = 0.3\,cm^{-3}$, $n = 3 \times 10^{3}\,cm^{-3}$

4) $\Omega = \pi\theta^2$



$\theta = \frac{R}{d}$

[from wikipedia]

$R = 1.22 R_\odot = 8.49 \times 10^{11}$ cm

$d = 1.33 pc = 4.10 \times 10^{18}$ cm

$\theta = 2.07 \times 10^{-7}$ rad

$\Omega = \pi\theta^2 = 1.35 \times 10^{-13}$ sr

$\Omega = 2\pi(1 - \cos\theta) = 1.35 \times 10^{-13}$ sr

Differ by $\frac{\Delta\Omega}{\Omega} = 3 \times 10^{-15}$