Week #5

Draine 2.3 a b c

Consider a dust grain of radius a, and mass $M \gg m_H$, where m_H is the mass of an H atom. Suppose that the grain is initially at rest in a gas of H atoms with number density n_H and temperature T. Assume the grain is large compared to the radius of an H atom. Suppose that the H atoms "stick" to the grain when they collide with it, so that all of their momentum is transferred to the grain, and that they subsequently "evaporate" from the grain with no change in the grain velocity during the evaporation.

(a) What is the mean *speed* $\langle v_H \rangle$ of the H atoms (in terms of m_H, T, and Boltzmann's constant k_B)?

(b) Calculate the time τ_M for the grain to be hit by its own mass M in gas atoms. Express τ_M in terms of M, a, n_H, and $\langle v_H \rangle$.

(c) Evaluate $\langle v_H \rangle$ and τ_M for a grain of radius $a = 10^{-5}$ cm and density $\rho = 3$ g cm^{-3}, in a gas with $n_H = 30$ cm^{-3} and $T = 10^2$ K.